TUSSOCK MOTH CONTROL

NORTH IDAHO
1947

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POTLATCH TIMBER PROTECTIVE ASSOCIATION
IDAHO STATE FORESTRY DEPARTMENT
U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

A REPORT

of the

TUSSOCK MOTH CONTROL, NORTH IDAHO
1947

By

JAMES C. EVENDEN
Bureau of Entomology and Plant Quarantine

and

E. J. JOST
Forest Service

A Cooperative Insect Control Project
Sponsored by

POTLATCH TIMBER PROTECTIVE ASSOCIATION

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ched is a copy of the report "Tussock Moth Control, North Idaho, " This report tells the story of a noteworthy achievement enabled gh the wholehearted cooperation of private landowners, State and ral agencies.

doubtedly, the project saved millions of feet of valuable timber which of great importance to the continuing economic and social well-being the inhabitants of northern Idaho and eastern Washington.

ther, the project was a complete demonstration of the feasibility of trolling what would otherwise be disastrous insect infestations in ble timber stands on our rugged western terrain. Only a few years such control methods would have been impossible.

hope you will find the contents of the report interesting as well as formative.

P. D. HANSON, Regional Forester

closure

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FOREWORD

The Tussock Moth Project of northern Idaho is considered a mark of progress in forest insect control. It is a forceable demonstration of what can be done in forestry with the full cooperation of private timber owners, State and Federal Governments. Without this cooperation the project would have failed. Much credit is due the Potlatch Timber Protective Association for their active participation, supported by their financial contribution. The State of Idaho made the project possible by passing necessary legislation and appropriating funds. The State Forester of Idaho and his staff cooperated in every possible way, besides contributing a major service in determining land ownerships and collecting funds from private timberland owners. The United States Weather Bureau provided a complete weather forecasting station which proved invaluable to the success of the operation. Many of the small timberland owners contributed funds to the work. The Forest Service carried the responsibility for the physical administration of the project, while the Bureau of Entomology and Plant Quarantine was charged with all technical phases.

The State Extension Service made a material contribution in arranging for meetings with private landowners and explaining the purposes of the project.

The Army Air Force made a highly valuable contribution through the loan of four truck tractors, ten tank trailers, and other equipment from Geiger Field, Spokane. Such essential equipment for distribution of the spray from the railroad to airfields was unavailable elsewhere.

The State Forestry Departments of Washington and Oregon assisted materially in obtaining State financial aid, and arranging for the treatment of the areas sprayed in those States.

The Moscow Chamber of Commerce and many individuals assisted in making suitable arrangements for use of airports and other facilities.

The University of Idaho provided space in one building sufficient for both headquarters office and sleeping quarters, which greatly facilitated the work.

A large share of the success of the project is due James C. Evenden of the Bureau of Entomology and Plant Quarantine and Jack Jost, who initiated the work, and untiringly continued through to its completion.

Great appreciation is extended to the many men not mentioned in the report assigned to the project by the State of Idaho, the Bureau of Entomology and Plant Quarantine and the Forest Service for their enthusiastic and fine work.

We were fortunate in having spraying contractors who were intensely interested in making the project a complete success. Their pilots were fine, well-trained young men, who did their utmost to do a good job of spraying - and they succeeded. Obviously we were all happy over the outcome of this operation. The results were all that could be asked for, and the work was finished on schedule.

P. D. Hanson

P. D. HANSON, Regional Forester

ABSTRACT

In 1946 a serious outbreak of the Douglas-fir tussock moth (Hemerocampa pseudotsugae McD.) occurred in Douglas- and grand fir forests of Benewah, Latah and Clearwater Counties in northern Idaho. A joint report of the situation by local officers of two Federal bureaus, the Bureau of Entomology and Plant Quarantine and the Forest Service, recommended an extensive control campaign for 1947. This recommendation echoed popular sentiment throughout the infested area. The present report gives in detail the many preparatory steps leading up to the organization of an aerial spraying program conducted in the spring of 1947 to suppress the outbreak, the methods used and the results.

The project, largest of its kind in the United States, began early in 1947 with private, State and Federal timberland owners cooperating. By agreement of these parties, the United States Department of Agriculture was delegated to carry out the details of the program. This Department, in turn, assigned the actual supervision to two of its subordinate bureaus; the Forest Service to handle the fiscal and administrative details and the Bureau of Entomology and Plant Quarantine the technical details.

Preliminary to the detailed planning of the project, enabling legislation was passed early in 1947 by the State of Idaho permitting State control funds totaling $210,000 to be administered by the Federal Government and authorizing the State Forester to declare a "zone of infestation" for the purpose of suppressing forest insect pests, the tussock moth in this case. A Federal appropriation of $395,000 was also passed by the 80th Congress for the tussock moth campaign. The large timberland owners agreed to pay an allocated share of the cost.

It was not until early in May that the Federal allotment was made signaling the start of full-scale preparations for the aerial spray project. Since March, however, preliminary surveys had been under way to determine the extent of the infestation to be treated. Contracts were let from bids received for DDT spray solutions and from aerial spray concerns, all contingent upon the approval of the project.

Beginning in May, project headquarters were established on the University of Idaho campus at Moscow, Idaho. Administrative and technical personnel were hastily recruited from northern Rocky Mountain national forests, various insect laboratories of the Bureau of Entomology and Plant Quarantine throughout the country, western forecasting stations of the Weather Bureau and from the Idaho State Forestry Department.

During the following 3 or 4 weeks a number of work projects were completed as a prerequisite to actual spraying operations. These included the surveying and construction of seven emergency air strips, the contacting of some 1,500 small timberland owners to secure their signatures on spraying agreements, the preparation of aerial photographs and maps for the spraying contractors showing location of treat and nontreat areas and other landmarks and the completion of the pre-control survey to determine the exact limits of the spraying.

While these were being done the Weather Bureau installed a complete local and distant weather forecast station at headquarters and the Forest Service set up a radio telephone communications system between headquarters and the air strips, field weather observers, contractors' headquarters and field supervisors' headquarters. Tests were also made of the airplane spraying equipment to insure proper performance and spray checking crews were trained for their forthcoming duties.

Spraying operations were begun May 22, 1947, and conducted intermittently due to bad weather until July 2. The spraying was done by two contractors; Central Aircraft Company of Yakima, Washington, and Johnson Flying Service of Missoula, Montana. Between them they used 11 planes, 8 being single-motored small planes of various models and the others being multimotored transport planes. Altogether these planes made 2,120 spray runs and deposited 390,878 gallons of DDT spray on 413,469 acres of forest land. This included 4,375 acres lying adjacent to the project in eastern Washington and 13,559 acres in northeastern Oregon which was subsequently added to the project.

Spraying was conducted between 4 a.m. and 9 a.m., weather permitting, because the cool, smooth air at those hours made for better plane maneuverability and better spray distribution. Evening flying was also done between 5 p.m. and 7:30 p.m. on days when weather permitted. Spraying was halted at least 1 hour before and during rainstorms and whenever the wind exceed 8 m.p.h. or thermal activity made flying dangerous.

The spray was compounded of technical DDT, 1 pound, in a solvent with light fuel oil to make 1 gallon. One gallon of spray, and hence 1 pound of DDT, was applied to each acre treated. The spray was shipped already mixed to Moscow, Idaho, in railroad tank cars by the two spray contractors, Stefan Chemical Company, Chicago, Illinois, and the Michigan Chemical Company of St. Louis, Michigan. From there it was transported to the various air strips by a fleet of 4,000-gallon, self-pumping, semi-trailer gasoline fuel tank trucks loaned to the project by the U. S. Army Air Force.

A large crew of spray checkers was used to obtain data on the size of spray droplets, amount of spray deposited, the swath widths and general spray coverage of each spray plane.

The spraying was entirely successful in killing nearly all tussock moth caterpillars in the treated area. No living caterpillars were found anywhere in this area following the spraying operations. The spray was applied in time to kill the 1947 brood of these insects before they had inflicted any appreciable damage, thus preventing a recurrence of the devastating defoliation of 1946.

It is estimated that the spraying prevented the almost certain defoliation of 1½ billion board feet of merchantable fir forests in the treated area valued at $4,328,000 and that another 1.2 billion board feet immediately adjacent was saved from possible defoliation. A total of 140,000 acres of fir forests, almost completely defoliated in 1946 but showing signs of recovery in 1947, would have undoubtedly been defoliated again and the entire stand killed had it not been for the timely application of the spray.

A study of the effects of the DDT on animal, bird and aquatic life made by biologists of the U. S. Fish and Wildlife Service showed no damaging effect to wild or domestic mammals, or to bird life. Game fish were not harmed but other aquatic life suffered in varying degrees from the effects of the DDT spray deposited in mountain streams.

This report concludes with an Appendix showing typical field forms used and a photographic summary of the project.

TUSSOCK MOTH CONTROL, NORTH IDAHO
1947

INTRODUCTION

During the past season one of the largest aerial spraying programs to be conducted on forest lands was successfully undertaken to control an epidemic outbreak of the Douglas-fir tussock moth (Hemerocampa pseudotsugata McD.) in north Idaho, Oregon and Washington. Because of its magnitude many technical and administrative problems were encountered which could not be solved on the basis of previous experience. A project of this size, involving a number of cooperators was, of necessity, rather complicated in its organization and activities, so much so that reporting upon the various phases is indeed difficult. This report deals with the spray program from the time of its inception until its completion. The details presented here are intended not only to describe the progress and results of the work, but to serve as an aid in planning future control projects of this nature.

To make this report of the Tussock Moth Control Operation, North Idaho, 1947, complete, it must start where the previous report of this insect infestation stopped. This previous report, "An Outbreak of the Douglas-Fir Tussock Moth in Latah and Clearwater Counties, Idaho, 1946," gave in considerable detail a description of the insect and its seasonal history; a record of past outbreaks; the existing situation; its economic importance; the ownership of the timberland involved; future of the infestation; difficulties of aerial spraying, and an estimated cost of the proposed operation. The operation admittedly would be an expensive one involving many technical difficulties. These, however, were relatively insignificant in comparison to the need for preventing serious damage to approximately 1.5 billion board feet of fir poles and saw timber valued at nearly $5,000,000. This report was presented to the regional forester and his staff at Missoula, Montana, on November 13, 1946. This recommendation was forwarded to the Forest Service, and the Bureau of Entomology and Plant Quarantine, at Washington, D. C., for their consideration.

Complete details of the tussock moth situation were presented to representatives of these two bureaus in Washington, D. C., on December 5, 1946. At this conference it was shown that funds and obtaining DDT would be the two principal hurdles to cross. With these problems solved, obtaining competent contractors to apply the spray would be an important consideration. As these items were not considered insurmountable, the conference recommended that the proposed project was feasible and economically necessary.

As shown in this report, there were many detailed and laborious tasks to be completed in the development of this project. The order in which these subjects are presented is intended to show in proper continuity the development of the operation, its start, and its completion. In this discussion there is some overlapping of time, as well as some duplication of material which could not be avoided.

PROJECT ORGANIZATION AND PERSONNEL

Since all classes of land ownerships were to be included by the spray program, its administration was bound to be complex. It appeared to be the consensus of the private, State and Federal agencies cooperating in the program that one agency should accept the responsibility of its administration. Because of its extensive holdings and technical knowledge, it was suggested that the Federal Government could best handle the administration of the project. Accordingly, to the United States Department of Agriculture went the task of planning and conducting the project. Two bureaus of this Department, the Forest Service and the Bureau of Entomology and Plant Quarantine, were delegated to carry out the actual supervision of details; the former assuming responsibility for the operational part of the project, the latter the technical controls.

While most of the work in carrying out these functions was undertaken by these two Federal bureaus, certain portions were entrusted to other agencies cooperating in the project. Personnel to carry out this plan was assigned from the regular staffs of these agencies, supplemented here and there by personnel hired on temporary appointments.

The following is a list of the agencies and their staff members who contributed their services to the tussock moth control project:

State of Idaho - Land Ownerships and Collections

Stanton G. Ready - State Forester, Boise, Idaho
Edward A. Ring - Assistant State Forester, Coeur d'Alene, Idaho
Thomas Crossley - Special Assistant State Forester, Coeur d'Alene, Idaho
Henry Jones - District Fire Warden, Kendrick, Idaho

Forest Service - Supervisory Staff

Paul H. Roberts - Project Leader, Regional Office, Missoula, Montana
Jack Jost - Assistant Project Leader, Regional Office, Missoula, Montana
E. H. Myrick - Public Relations, Lolo National Forest, Missoula, Montana
George Duvendack - Project Administrative Officer, Kaniksu National Forest, Sandpoint, Idaho
N. L. Henry - Project Administrative Assistant, Regional Office, Missoula, Montana
Serge Skoblin - Superintendent of Engineering, Regional Office, Missoula, Montana
Don Chamberlain - Transportation and Supply, Nezperce National Forest, Grangeville, Idaho
Larry Wilkinson - Communications, Regional Office, Missoula, Montana
Luana Sylvester - Clerk-Stenographer, Moscow, Idaho

Bureau of Entomology and Plant Quarantine - Supervisory Staff

W. L. Popham - Assistant Bureau Chief, Charge of Technical Phases of Project, Washington, D. C.
James C. Evenden - Field Representative, Assistant in Charge of Technical Phases of Project, Coeur d'Alene, Idaho

Archie L. Gibson - Pre-Control Survey, Coeur d'Alene, Idaho
Philip C. Johnson - Berkeley, California
John Regan - Checking Supervisor, Greenfield, Massachusetts
Archie Gieser - Bureau Pilot, Spraying Advisor, Denver, Colorado
Violet Barber - Clerk-Stenographer, Coeur d'Alene, Idaho

Weather Bureau - Supervisory Staff

Ralph T. Hanna - Meteorologist, Western Fire Weather Coordinator, San Francisco, California
Wilbert R. Krumm - Associate Meteorologist, Missoula, Montana
Charles Syverson - Assistant Meteorologist, Missoula, Montana

PUBLICITY

During the summer of 1946 the discolored foliage of trees attacked by the tussock moth presented a spectacular sight, covering, in many instances, whole mountainsides. As these discolored mountainsides, containing thousands of acres, were visible for miles along well traveled highways, a far-reaching interest in the infestation was aroused. With this interest came requests from a number of local organizations for the tussock moth story. This story was told at the annual meeting of the North Idaho Chamber of Commerce in Moscow, Idaho, on November 21; to the North Idaho Forestry Association on December 8; the Northwest Scientific Association at its annual meeting in Spokane on December 27; and to the Hoo Hoo Club, a lumbermen's group, in Spokane on January 3, 1947. At all of these meetings an active participating interest was shown. This interest continued through the duration of the project and the subsequent recording of the results.

When funds for control seemed assured, a meeting of all agencies was held in Spokane, Washington, on March 11, 1947. In discussing the details of the proposed operation the need for an organized and properly directed program of publicity was recognized. To meet this need the following public relations committee was appointed: James C. Evenden, Chairman, Bureau of Entomology and Plant Quarantine; Ray Fitting, Forest Service; Edward Ring, State of Idaho; and Leo Bodine, Potlatch Lumber Company. It was apparent to this committee that an information officer was required who would work in close cooperation with this committee in answering the many requests for information which eventually came from the public and from newspapers and feature writers. Accordingly, Supervisor Eldon Myrick of the Lolo National Forest, Missoula, Montana, was assigned to this position. Widespread interest in the tussock moth project was evidenced by the many newspaper and magazine articles which have appeared.

As the preliminary work tasks associated with this project were started, a series of educational meetings was held throughout the zone of infestation. Splendid assistance was given to the committee by County Extension Agents McProud, Brooks and Kambitsch of Latah, Clearwater and Benewah Counties, respectively. State Forester Ready, Extension Forester Ravenscroft of the University of Idaho and his assistant, Mr. Vernon Burlison, assisted in the following program as given at most meetings:

Introduction	- E. H. Myrick
Importance of Farm Forestry	- Vernon Ravenscroft
The Tussock Moth, Its Seasonal History and Control	- James C. Evenden
Problems of Aerial Spraying	- Jack Jost
Financial Phases of the Project	- Stanton G. Ready

Meetings were held at the following places:

March 2 - Timber Products Bureau, Spokane, Washington
10 - North Idaho Forestry Association, Spokane, Washington
April 4 - County, State, and University of Idaho Representatives, at Moscow, Idaho
12 - Cedar Ridge Grange, Cedar Ridge, Idaho
14 - Troy Chamber of Commerce, Troy, Idaho
15 - Latah County Chamber of Commerce, Bovill, Idaho
16 - Farmington Grange, Farmington, Washington
17 - Coeur d'Alene Chamber of Commerce
18 - Princeton Grange, Princeton, Idaho
19 - Deary Grange, Deary, Idaho
May 26 - North Idaho Chamber of Commerce, Salmon, Idaho
June 14 - Santa Grange, Santa, Idaho

The program given at these meetings was planned to present information which the residents within the area to be sprayed wanted to hear. Misinformation and rumors had circulated during the early planning of the project and some fear existed as to the possible injurious effects of DDT to persons, certain crops, farm animals and wildlife. The information given at these meetings by those in charge of the project, and later in press releases prepared by Mr. Myrick, served to dispel these fears to everyone's satisfaction. No belligerence or disapproval of the proposed operation was expressed at any meetings.

For the most part all residents within the spray area were entirely satisfied with the work as conducted. There were a few complaints which, upon investigation, proved to be ill-founded. Most residents were pleased at the absence, temporary of course, of flies and mosquitoes over wide areas. Many farmers and ranchers asked for arrangements making it possible to treat infested shade trees around farmhouses. These were subsequently made at a small expense to the owner.

APPORTIONING THE CONTROL COSTS

As this project involved private, State, and Federal lands it was necessary that the cost of control be carried by all owners on an equitable basis. Obviously the interest of the commonwealth in this serious situation justified the Federal and State Governments carrying a major portion of the expense. On this premise, the following formula for payment was adopted as satisfactory to all concerned. The United States would pay for control on Federal lands while the State of Idaho would pay for all State and county land similarly treated. The cost of control on private lands would be borne by the United States, the State of Idaho, and the owner as follows: United States, 50 percent, State of Idaho, 25 percent, and the private owner, 25 percent. As the cost of treatment had been estimated at $1.70 per acre, this would make the payments for private lands as follows: United States $0.85, State of Idaho $0.425, and the private owners $0.425.

It was realized that voluntary payments from many owners of small timbered tracts would not be forthcoming. In this event, the United States and the State of Idaho together agreed to assume any deficit which might result on a 50-50 basis. As the amount of this deficit could hardly be anticipated, the exact amount of the State and Federal appropriations could not be set. To meet this eventuality, estimates for Federal and State funds included amounts assigned small owners under the formula. Subsequent collections of these payments, then, had the effect of reducing the cost of control for both the Federal and State Governments.

APPROPRIATION OF FUNDS FOR CONTROL

Lumber Companies

Directors of the Potlatch Timber Protective Association met in Spokane, Washington, on January 24, 1947, to determine the position the association should take in relation to the proposed control operation. The tussock moth story, with existing plans for control as developed at that time, was presented in considerable detail. It was then unanimously decided that in view of the seriousness of the situation the association would carry its share of control costs.

The Potlatch Timber Protective Association was the first land managing agency to make their control funds available. Credit is indeed due this association as their voluntary participation in this forest protection program established a pattern of cooperation that was not overlooked by other agencies concerned. This attitude bids well to the building of sound, country-wide, forestry practices.

State of Idaho

Obtaining funds for the State of Idaho to carry its share of the proposed control operation was a responsibility of the State Forester's office. On January 17, 1947, the tussock moth story was presented to a special meeting of the Idaho State Cooperative Board of Forestry at Boise, Idaho. At this meeting the board recommended that the State cooperate with private owners and the Federal Government in the control of this infestation, and that the State Legislature appropriate the necessary funds to carry its share of the costs. On February 20, the existing situation and the future potentials of the tussock moth infestation were presented to a special meeting of the appropriation and forestry committees of both the Idaho Senate and the House of Representatives. Credit is due State Forester Ready for his tireless efforts, which were rewarded by House Bill No. 218 appropriating $210,000 for cooperative forest insect pest control, subsequently approved by the State Legislature on March 4.

United States

Early in January 1947 the Bureau of Entomology and Plant Quarantine and the Forest Service together prepared a report covering estimates of control funds needed for 1947. This report was presented to the Secretary of Agriculture for consideration and, following his approval, it was forwarded to the Bureau of the Budget. On February 14, the President of the United States referred to the Speaker of the House of Representatives a Budget Bureau statement which included an estimate for tussock moth control as follows:

"For expenses necessary to enable the Secretary of Agriculture to carry out operations, independently or in cooperation with State agencies, associations, organizations, or individuals, to combat an outbreak of tussock moth, $395,000, to remain available until December 31, 1947: Provided, that no part of this appropriation may be used to pay the cost of property injured or destroyed - $395,000."

At a later period the subcommittee of the House Committee on Appropriations held hearings on this request. Representatives of the above two departmental bureaus again appeared before this committee in connection with this estimate. Firm belief in the merits of the appropriation was evidenced by the fact that on May 1 it was made available by the President's signature.

When the appropriated money was made available to the Department of Agriculture, the Bureau of Entomology and Plant Quarantine and the Forest Service joined in a recommendation to the Secretary of Agriculture on how the funds should be allotted between these two agencies. There was joint agreement that the major portion of the money be allocated to the Forest Service to handle the cost of the operational phases of the project. The remainder of money was apportioned to the Bureau of Entomology and Plant Quarantine to provide for technical supervision of the project.

Private Owners of Small Timber Tracts

Collections of control funds from the private owners of small timber tracts was an important part of this project carried by the State Forester and his staff. These collections were difficult and laborious as more than 1,500 private owners were involved. Payment was entirely voluntary and it was necessary for the State Forester to execute a separate contract with each owner.

Preparatory to this task it was necessary to determine the ownership of each area to be treated, the owner's address, and the acreage of the area to be treated. There were many nonresident owners, as well as owners with uncertain addresses, which had to be located. There were numerous instances where the same individual owned timberlands listed for treatment in different portions of the zone of infestation. This condition made it necessary to obtain a complete roll of all privately owned lands to be treated before any assessments could be made. Unfortunately, it was necessary that this roll be prepared from the description of areas which the pre-control survey listed for treatment. As this work was not completed until early June 1947, the work of collecting these funds was delayed accordingly. This handicap to the progress of this assignment was unfortunate, but under existing circumstances could not be avoided.

PREPARATORY WORK PROJECTS

In considering this project it was believed that preparations would have to begin by March 1, 1947, in order to complete and execute the plans. This was done even though the project was not definitely assured until Federal funds were appropriated on May 2. The fact that State and private funds were appropriated much earlier was of little consequence in guaranteeing an earlier start of preparations since these funds were made available contingent upon appropriation of Federal funds.

In order that vital preparatory work could be started without delay the sum of $10,000 was advanced to the tussock moth control project from the regular Insect Control Appropriation of the Forest Service, for the fiscal year 1948.

Before actual spraying could begin there were many details to be arranged for and much information to be compiled. The dead line for completion of most of this work was set for May 22, the latest date actual spraying could begin and still be completed by July 1 when its effects on the 1947 tussock moth population would begin to be less effective. This meant that a great deal of work had to be done in a comparatively short time. In view of this and of unforeseen details, it was inconceivable that this could be accomplished without a certain amount of confusion. Suffice to say, most of the preparatory work was completed on schedule with no resultant delays to the inauguration of the spraying program. The various activities concerned with this phase of the project are described in some detail under the subheadings which follow.

Project Headquarters

One of the first activities following the organization of the project was to establish a headquarters. In this, the University of Idaho aided materially in providing quarters and furnishings to house the administrative and supervisory staff and its equipment on its campus at Moscow. In addition to administration, such activities as weather forecasting, radio telephone communications, engineering and spray supply were set up and conducted at this headquarters.

Survey and Construction of Temporary Air Strips

Within and adjacent to the infested area there were only two airfields which could be used in carrying out the proposed spraying program. One was the Moscow-Pullman Municipal Air Terminal, situated midway between the cities of the same names in Idaho and Washington, respectively. The other was located at Elk River, Idaho. It was obvious that, to meet the requirements of the project, other air strips would need to be provided. It was recognized that the number, size and location of these temporary fields would depend largely upon the type of airplanes used by the successful contractor. However, it was necessary that these items be determined sufficiently in advance of the spraying operation to provide the time for construction. Original plans to locate landing strips within a maximum radius of 12 miles from the areas to be treated were abandoned as being economically impracticable.

The location and construction of these emergency fields was the responsibility of Mr. Serge K. Skoblin, airfield engineer, Forest Service, Missoula. Available aerial photographs were examined to determine possible locations. Extensive surveys were then made to obtain an estimate of the cost of construction, and to determine if the area was suitable and if the land could be leased. Considerable difficulty was experienced as some locations were found to be a mass of mud while others were covered with as much as 2 feet of snow. The preliminary survey was begun on February 5 and enabled the selection of desirable locations despite the adverse weather conditions which prevailed during the time it was made.

Moisture condition on the ground did not permit the actual construction of these fields to start until May 2. This situation made it necessary to disregard any priority that might have existed in their construction and to work on the high, drier sites first. This resulted in some duplication in the transportation of equipment, which was unavoidable. A total of seven fields were constructed during the period from May 2 to June 6. As these fields were temporary in character, construction was limited to the required necessities of usability and safety, time being a primary factor. Obviously these fields were of much lower standards than would have been acceptable for more permanent use. Their requirements were as follows:

1. To be 1,800 feet in length, and more if above 4,000 feet elevation.

2. To be 100 feet in width.

3. To have 3,000 feet clear approaches at either end of field.

4. Runway to be smooth and compact.

5. Runway to have good drainage to carry surface water away.

6. Subgrade to be free of excess moisture with good drainage to avoid accelerated softening of the field by the impact of travel.

7. To be accessible by good roads.

In the construction of these fields, Mr. Skoblin used two crews, each composed of the following personnel and equipment:

Personnel	Equipment
1 foreman	1 TD-18 tractor - trailbuilder
1 power grader operator	1 motor patrol
1 tractor and scraper operator	1 scraper - 8 yard
1 truck driver	1 convey luber
1 laborer	1 roller sheepsfoot or three wheel
	1 1½-ton truck
	1 ¼-ton truck

Although these fields were rough, and of a decidedly temporary character, they were satisfactory for the use intended. Unfortunately, the strips constructed in the southern portion of the area did not dry out in time for use by the larger planes used by one of the spraying contractors. At times the extreme dryness of these dirt fields proved to be a handicap which was not foreseen. At one time the Princeton field was so dusty as to be quite injurious to airplane motors and to slow take-off and landing operations. Sprinkling equipment was obtained as quickly as possible and this condition alleviated. (See plate I)

Land Ownership

In the early planning of this project it was necessary to have, under each class of ownership, information on the percentage of timberlands requiring treatment. This was needed to establish the allotment of funds which would be required from each land managing agency. As more than 1,500 owners of

small timber tracts were involved this proved to be a detailed and tedious task. This work was conducted by officers of the St. Joe National Forest during the month of October 1946. The following data resulting from this work proved quite adequate in showing the division of ownership of the lands containing infested timber:

Ownership of Lands Within Infested Area
State of Idaho

Ownership	Acres	Percent
Federal	58,521	14.80
State of Idaho	52,387	13.24
Large timber owners	115,804	29.28
Small timber owners	168,823	42.68
	395,535	100.00

During February 1947 these same officers were assigned to the task of obtaining ownership data. County records were searched to obtain each owner's name and address, the legal description of his land, and the net timbered acreage involved. These records later were of material assistance to the Idaho State Forestry Department in their assigned task of collecting control funds from the owners of privately owned timberlands.

Federal-State Cooperative Agreement

Existing laws prohibit the United States Government from going upon State or private lands to conduct insect control without proper authority. For the State of Idaho to grant such authority it was necessary to obtain the passage of specific State legislation. Idaho Senate Bill No. 118, which gave the State Forester, or his agent, the right to declare "zones of infestation" and to go upon private lands within such zones to conduct control measures, was enacted into State law on February 18, 1947. The problem of administration was then cleared as the State Forester appointed the United States Forest Service as his agent.

To further establish the legality of the United States to carry out the provisions of this project on State and private lands, a formal agreement between the State of Idaho and the United States Government was signed on April 17, 1947. The most important items of this agreement are stated as follows:

1. Appointed the Regional Forester, Forest Service, Region One, as the agent of the State of Idaho to conduct the proposed control operation.

2. Made the Bureau of Entomology and Plant Quarantine responsible for the technical phases of the project.

3. Established the formula for the payment of control costs by different land ownerships, and provided for carrying any deficits which might result from the nonpayment of private owners.

4. Made the State responsible for the collection of control funds from private owners.

5. Established the fiscal procedure for the payment of State and private funds to the cooperative work fund of the United States Forest Service.

6. Set the spray formula as "not more than 1 pound of technical DDT in solvent and fuel oil to make 1 gallon of spray, to be applied at the rate of 1 gallon per acre."

7. Provided for the termination of the agreement in the event it was subsequently found by the Bureau of Entomology and Plant Quarantine that control would not be necessary.

8. Provided for a refund to the State Treasurer of State and private funds paid into the cooperative work fund and not used.

9. Relieved the United States from any public liabilities arising from the operation.

As the tussock moth infestation extended over the Idaho State line near Tekoa, Washington, it was necessary to obtain similar authorization from the State of Washington before this small area could be treated. Fortunately, existing Washington State laws permitted the State Forester to appoint the United States as his agent for the purpose of controlling the infestation on privately owned lands. A formal agreement covering this cooperation was made with the State of Washington. This agreement was similar to the one made with Idaho, except that the collection of funds from the private owners was made by the Forest Service. No State lands were involved.

Late in the duration of the project some 13,600 acres of tussock moth infestation on the Umatilla National Forest of Oregon were added to the area to be treated. This additional acreage also required a formal agreement with the State Forester of Oregon before spraying could be conducted. This agreement followed the same general pattern as the Idaho covenant. In this instance the State paid the share of the private owners as collections were considered impossible.

Aerial Photographs

Aerial photographs were essential to the work of the pre-control survey, as well as to assist the contractors in dividing the areas to be treated into small work or spray units. Fortunately, practically all of the area under consideration had been covered by aerial photography in 1933. Although it was realized that in some instances such photographs would not be entirely accurate due to intervening changes in land management status, they were considered satisfactory for the purpose intended. Aerial photograph negatives of the northern portion of the zone of infestation were in the possession of the Forest Service, while those of the southern areas were held by the Soil Conservation Service. Arrangements were made with both these agencies to obtain a complete set of contact prints and certain enlargements.

These photographs, printed on double-weight, semi-matte paper, were made available for use in early April. The contact prints were scaled to approximately 3½ inches to 1 mile, while the enlargements were 6 inches to the mile. The value of the photographs was increased materially through

the addition of section lines by the Division of Engineering, Forest Service, Missoula. Without these lines the use of the photographs would have been quite difficult and limited in scope.

Pre-Control Survey

An extensive survey conducted in 1946 showed an area of some 497,000 acres containing active tussock moth infestations. It was then estimated that 100,000 acres would be eliminated from this total as not requiring treatment. This elimination would include farmlands, forest meadows, burns, cut-over lands, nonhost timber types, and areas where infestations were absent or too light to warrant treatment. It was upon an estimated net infested area of 350,000 acres that this project was based. This estimate proved to be about 45,000 acres low. Fortunately, the cost of the operation was subsequently reduced from an estimated $1.70 per acre to approximately $1.57. This saving made it possible to treat this increased acreage with even less money than was allotted for the original area.

To show the actual location and acreage of the areas requiring treatment, it was necessary to supplement the extensive survey with a fairly intensive survey of the zone of infestation prior to control. This was started on April 14 and it was planned to complete the work by or soon after the 20th of May. The work progressed rapidly in all accessible areas, but as higher elevations were reached, snow and impassable roads delayed its completion until the early part of June. While this survey kept well ahead of the spraying operation, it would have been better to have had this task completed prior to the start of spraying operations. This delay was a handicap to State officials in preparing for the collections of control funds from many private owners of timber tracts.

This survey was conducted by a crew of seven men detailed from the Forest Service and placed under the supervision of the Bureau of Entomology and Plant Quarantine. Three crews of two men each were assigned to separate portions of the infested area. One man was assigned to the compilation of maps, computing of acreage, etc. Aerial photographs were used by crew members to identify and accurately locate the forest area under consideration. By taking advantage of lookout points, roads and open ridges, a crew of two men often covered several sections in a day. Field glasses aided materially in determining the severity of the 1946 defoliation in isolated places. A mimeographed form (see Appendix Form 1) was provided on which the required data from one or four sections could be carried. Space was provided for a rough sketch of the timber stands as identified from the photograph.

Field data sheets with the aerial photograph to which they referred were passed to the chief of party. A decision was then made as to the necessity for control, and the aerial photographs marked accordingly. (Fig. 1)

In instances where the data submitted were not in sufficient detail, rechecks were made by other officers of the Bureau of Entomology and Plant Quarantine before a final decision was made. Planimeters were used to determine, from the aerial photographs, the acreage of the areas marked for treatment. This acreage was shown on the marked photograph, and compiled by sections for each township.

Figure 1. Aerial photographs were used to show timbered areas to be treated and to determine the acreage of such areas. The area contained in the large square represents (one section of land) roughly 1 square mile. Light-colored areas are nontimbered and marked by red hatching to indicate no treatment. (1294)

After this information was transferred to base maps and compiled in township lists, the marked photographs, with a copy of the township list, were passed to the spray contractors.

Pre-Control Entomological Studies

Following the tussock moth control recommendations made in the fall of 1946 the Bureau of Entomology and Plant Quarantine, through its forest insect laboratory at Coeur d'Alene, Idaho, began a series of studies of the prevailing tussock moth infestation. These were aimed at finding out, if possible, what course the infestation was to take in 1947. The magnitude of the infestation then would determine to a large extent whether control was justified and, if so, what the probable expenditures would have to be to do the job adequately.

The 1946 studies considered, for one thing, the probable effect of parasitism. Some mortality data on this phase were obtained but evaluation was difficult in view of the lack of previous information with which to base a comparison.

Later in the season a quantitative comparison was made of the 1945 and 1946 tussock moth egg masses and the result proved to be a good criterion of the probable tussock moth population which could be expected in 1947. The 1946 egg masses, for instance, were 450 percent greater than the number produced in 1945. This strongly indicated that a heavy 1947 moth population was almost assured unless something unforeseen happened to the eggs during the 1946-47 winter. To detect any possibility in this direction, egg masses were collected from the infested forest areas every 2 weeks during the

winter. Their viability was tested by holding them at room temperature to facilitate hatching.

During the winter the average number of caterpillars originating from each egg mass was 131. This figure was reduced to 65 in April 1947 when egg parasites became active. Despite this reduction it was felt that the 1947 tussock moth population would still be greater than the one which caused so much widespread damage in 1946. This evidence was largely responsible for the decision to go through with the 1947 control project as recommended.

Another phase of these studies helped determine the effectiveness of the spray mixture contemplated by the project and, indirectly, the timing of the spray program. It was previously known, and substantiated on this project, that the spray formula would be most effective on the younger caterpillars. The date which spraying must start was, therefore, determined as the date when the first caterpillars began to hatch from the overwintering eggs - arbitrarily established in the case of this project as May 22.

Normal life history of the tussock moth was again checked in 1946 and found to be as indicated in plate XIV. The greatest damage to fir foliage was the result of the voracious feeding of the smaller, or younger, caterpillars. Less feeding, and hence less damage, was done by the more mature caterpillars.

Aerial Spraying Contracts

In letting aerial spraying contracts for the application of 350,000 gallons of spray, it was necessary that they be awarded in time for the successful bidder to prepare his equipment by May 20, 1947. To meet this requirement "Invitations to Bid" were issued prior to funds being available, and an award was made contingent upon this fact. With no previous contracts of this character to serve as a guide, the preparation of this bid proved to be a rather difficult task. However, a draft which satisfied the field requirements of the Forest Service and the Bureau of Entomology and Plant Quarantine was prepared and submitted to the Washington office of these bureaus on March 15. Considerable revision proved necessary, and the opening of the bids was postponed from April 1 to the 14th. Although this "Invitation to Bid" was sent, in many instances by request, to 27 flying firms, only 5 bids were received. On May 7, 1947, the Secretary of Agriculture approved the bid submitted by the Johnson Flying Service of Missoula, Montana, and the Central Aircraft Inc. of Yakima, Washington.

The bid invitation was not altogether satisfactory with regard to the specifications of aircraft and spraying apparatus. This could not be helped because there was very little information on the use of existing equipment on projects with conditions comparable to the proposed tussock moth spraying operation.

The bid did state that, in the past, certain performance was obtained from different types of spray planes, but that this could not be construed as meaning that equal performance could be expected from similar planes the bidder might use. The invitation, therefore, specified that flight tests would be made of the bidder's plane equipment prior to the date spraying operations were to begin.

No mention, however, was made in the bid invitation of any spray apparatus which the bidder might use, nor was this included in the bids submitted. The two successful bids were awarded before the equipment of either flying contractor was known to the project administrators. Tests were made by a representative of the Bureau of Entomology and Plant Quarantine as soon as the equipment was ready for operation, only a few days before spraying was to begin. The equipment of each airplane was found to be capable of providing the required per-acre dosage of DDT spray mixture. This was indeed fortunate because the spray program could have been delayed and its value jeopardized while the inadequate equipment was modified or replaced. An excellent job of figuring spray equipment requirements to meet the dosage of 1 gallon per acre was done by the flying companies' engineers. Only minor alterations were suggested after the test flights.

To forestall any possible delays and to make certain that more control is had over the types of airplanes and spraying apparatus which may be used, future bid invitations should specify what types of spray equipment will or will not be considered adequate.

Provision should also be made for the bidder, in submitting his bid, to describe the spray equipment he intends to use. Finally, the bid invitation should make it clear that any or all the successful bidder's equipment may be examined or tested by project technicians sufficiently in advance of the beginning of spray operations to permit the replacement of defective or inadequate equipment.

Spray Material Contracts

It has been stated that in planning this project the availability of DDT appeared to be a determining factor. However, at the time of the Washington conference it was believed that it could be obtained. The task of obtaining around 350,000 gallons of DDT liquid insecticide was assumed by the Washington office of the Bureau of Entomology and Plant Quarantine. Mr. Rohwer, assistant chief of this bureau, obtained the required amount of DDT, and was successful in having a formulated (ready for use) spray delivered in tank cars. This plan eliminated the necessity for mixing the spray, which is quite difficult, at the Moscow, Idaho, railhead.

Contracts for the formulated DDT spray mixture were awarded to the Stefan Chemical Company, Chicago, Illinois, and the Michigan Chemical Company, St. Louis, Michigan. These two companies together furnished a total of 390,878 gallons of the spray mixture delivered in railroad tank cars to Moscow, Idaho.

The freight charge for this material, which was equal to 23 percent of the spray cost, was apparently based on a finished product tariff. Although the administration of the project was simplified materially, possibly a concentrated DDT solution to which fuel oil could be added at the railhead would be more economical. Balanced against the saving from a lower tariff would be the cost of mixing, entailing added personnel, equipment to mix large amounts of spray solution quickly, and a certain amount of wastage in handling.

As each tank car of spray was received at Moscow, a sample was taken and sent to the Division of Insecticides Investigations, Bureau of Entomology

and Plant Quarantine, for analysis. Detailed reports of the analyses returned by Dr. R. C. Roark, in charge of this division, showed that the spray materials were formulated to meet contract specifications.

The contract covering the purchase of this spray stressed the following specifications: Standard Government-approved formula to be used, type of insecticide, material and workmanship, general requirements, detailed requirements and packaging. This resulted in a 12 percent DDT spray solution composed of 1 pound technical DDT dissolved in 1 gallon of mixed solvent composed of 15 parts (by volume) of auxiliary hydrocarbon solvent and 85 parts Diesel Type A fuel oil.

The requirements of the contract as to delivery were complied with satisfactorily, but, notwithstanding this, a considerable part of the limited spraying time was lost because of "no spray." This condition arose from circumstances which could not be foreseen. First, spray was applied at a faster rate than had been anticipated, because of the efficiency of the contractors and longer spraying periods. Delay in rail shipments in June due to mid-west floods was another item over which there was no control. As soon as these conditions were recognized the chemical companies were asked to push their shipments as rapidly as possible. That they not only supplied the designated volume of spray in the time allotted, but an additional ~~42,000~~ 40878 gallons as well, is ample evidence of their cooperation.

Weather Bureau Cooperation

Inasmuch as weather could well determine the success or failure of the proposed project, it was realized that a knowledge of the weather to come would be an invaluable service. To provide this the United States Weather Bureau established a complete weather forecasting station at the project headquarters in Moscow at no expense to the project. This station was equipped with teletype receiving sets which recorded both the "A" and "C" weather data circuits and operated on a 24-hour basis.

Local weather stations were established at Forest Service fire lookout stations on East Moscow and East Dennis Mountains, and at each operating airfield. Starting at 2 a.m., hourly observations were taken at all stations and continued through the morning spraying hours. These were resumed again at 2 p.m. and continued through the afternoon in the event spraying was conducted. At times special midday and evening weather reports were required from these stations to properly plan for subsequent forecasts. It is believed that some improvements could have been made in the local data obtained. More stations have been suggested, with some mid-points between the mountaintops and the operating airfields.

From the data received the Weather Bureau staff issued a twice-daily formal weather forecast over the project's radio telephone communications system. The first of these was released at 3 p.m. and gave a broad, general forecast of conditions to be expected during the period from sunrise to sunset of the following day. It also contained information that determined the feasibility of spraying later the same evening. The second, or so-called spraying, forecast was released at 3 a.m. This forecast checked the information issued the previous afternoon and provided local information which permitted a decision as to early morning spraying. The information provided in these forecasts is shown in Appendix Form 2.

Since it was essential that every hour of spraying weather be utilized, the service given by the Weather Bureau proved indispensable to the success of the project. Obviously, the value of such service is in direct ratio to its accuracy. On the tussock moth operation the forecasts were as near 100 percent accurate as could be obtained. Project officers and contractors alike soon learned to depend with utmost confidence upon these forecasts in scheduling their day-to-day spraying operations.

Communications

Radio and telephone communications were established early in the project between the headquarters in Moscow, Idaho, and the project's field weather observers, contractors' headquarters, operating air strips and headquarters of the field supervisors. The radio service was particularly helpful to the Weather Bureau staff in obtaining local weather reports from the project field stations and in releasing forecasts to the spraying personnel.

Radio installations were provided and maintained by the Forest Service, using their standard "M" set at Moscow and "SPF" sets in the field. Broadcast schedules were set up to transact weather and spraying orders, but on days when spraying was in progress the operator at Moscow was "on the air" nearly 18 hours steady. In future installations of this kind it would seem desirable to provide an additional operator.

SPRAYING OPERATIONS

Aerial Spraying Equipment

Airplanes used on the tussock moth project represented a wide variety of models, sizes and performance. The Johnson Flying Service used one Douglas C-47 twin-motored transport plane and two Ford tri-motored transport planes. The Central Aircraft Company relied upon eight smaller single-motored planes comprising Stearman biplanes and Stinson, Fairchild and Travelair monoplanes. All monoplanes were of the high-wing type. These were the spray planes. In addition each contractor used one or more single-motored planes to supply their own bases and to show the spray pilots their assigned spraying units. These were also available to the project supervisors in laying out units, checking spray plane performance, and for photography.

The spray apparatus with which the spray planes were equipped was more standardized. Spray tanks were installed in the fuselages and wind- or power-driven pumps maintained a pressure in the tanks and distributing systems. The C-47 used a venturi-type nozzle under the fuselage while the remainder of the planes used pipe spray booms mounted under the wings. Spray solution was emitted from these by small holes or through regular spray nozzles spaced at intervals along the booms. A more complete description of this equipment is given in the Appendix and portions of it are pictured in plates II to V.

The spray equipment used by each contractor appeared to be well designed and constructed and very little lost time was attributed to break-downs of this equipment. In a few cases the spray mixture continued to drip from the closed nozzles due chiefly to foreign particles collecting in them. In one instance, failure to keep the nozzles clean resulted in some complaints

by farmers lying in the path of ferrying planes, who thought their property was being sprayed time and time again. Enough spray solution dripped from the closed nozzles to give the illusion in the sunlight of full-volume spraying, though actually this came from the small amount of solution left in the boom when the spray valves were closed.

Effective Performance of Spraying Equipment

Spray dispensing equipment on all planes was checked prior to and during the spraying operation as to droplet size, effective swath width, and its ability to deliver a steady flow of spray of a required volume to obtain a coverage of 1 gallon per acre. Following the initial checks, which were conducted under rather optimum conditions, the following swath widths and spray delivery were assigned to each plane:

Type of plane	Number of planes	Speed (m.p.h.)	Spray load (gallons)	Swath (feet)	Delivery (gals./min.)
Douglas C-47	1	140	1,000	400	112
Ford Tri-Motor	2	90	400	300	54
Fairchild	1	90	300	200	36
Travelair	2	90	200	200	36
Stinson SM7A	1	85	150	175	32
Stearman	4	80	75	100	16

It will be seen that the assigned swath width and the flying speed governed the rate of spray delivery. Had a heavier dosage per acre been required, it would have been necessary to reduce the assigned swath width of several planes, as the delivery rate could not have been adjusted. The rate of delivery for the Douglas C-47 was 112 gallons per minute, which was near its maximum. The assigned swath widths were less than the actual spread of the spray. This overlap provided a safety factor which was necessary in assuring a proper coverage.

At the proposed dosage of 1 gallon per acre a total of 413,469 gallons of spray solution would have had to be applied to cover the 413,469 acres sprayed. Actually, 390,878 gallons were applied, a shortage of only 5 percent, which is considered remarkable in view of the absence of any ground markers or other artificial aids to assist the pilots in an even distribution of spray. This difference between estimated gallonage and the gallonage actually applied is insignificant and needs no explanation. It could have been due to an insignificant limit error in calibration of spraying equipment, the pilots' interpretation of spray units, or to the fact that much of the flying was done "down slope" so that the resultant increase in plane speed without corresponding increase in the delivery rate of the spray solution produced a slightly lighter dosage per acre.

Transportation of Spray From Railhead

The contract awarded for the application of spray required the successful bidder to transport the mixed spray from the tank cars at the Moscow railhead to the airfields. Passing the responsibility for this phase of the project to the contractor relieved the project administration from the many additional problems associated with the task, and was an economical procedure. Although tank trucks for this purpose were provided by the

Government, the contractor furnished all personnel and paid for the cost of operation, maintenance, and repairs of this equipment. Each contractor was also required to carry public liability and property damage insurance of not less than $20,000.00 and $10,000.00, respectively, applicable to any Government-owned vehicle being driven.

The spray tank trucks were obtained on a temporary loan from the U. S. Army Air Force to the Forest Service at no cost. This equipment consisted of the following:

1	4-wheel truck tractor
4	6-wheel, 6-wheel-drive, truck tractors
2	2,000-gallon tank trailers
8	4,000-gallon tank trailers
5	2-wheel trailer dollies

Each of the semi-trailer tank units was equipped with two power pumps with a free-flow delivery of 80 gallons per minute. The operation of these pumps was reversible so that spray could be pumped from railroad tank cars to the tank trucks and from tank trucks to airplanes. Each pump was equipped with 50 feet of 1½-inch hose mounted on an automatic reel. This equipment proved very satisfactory and successfully solved the problem of spray transportation in the field. (See plate VI)

Application of Spray

In the application of spray (see plates VII-IX), the Central Aircraft Company operated as a unit in the northern portion of the area, using the temporary air strips at Princeton, Laird Park and Tensed, Idaho, while the Johnson Flying Service worked the southern areas from Moscow-Pullman airport and the temporary air strip at Elk River. (See map, plate XII) The total acreage treated by each company was as follows:

Contractor	Idaho	Washington	Oregon	Total
Central Aircraft	193,265	4,375	--	197,640
Johnson Flying Service	202,270	--	13,559	215,829
	395,535	4,375	13,559	413,469

To assist in planning for the application of spray, each operator was provided with aerial photographs showing the areas to be treated, forest maps, and lists of acreages for each section. This material was used to establish individual spraying or flight units used by each pilot. These usually averaged from 1,000 to 3,000 acres in size. Wherever possible ridges, streams, roads, and fields were used as unit boundaries, but flight lines or unit boundaries were not artificially marked. Unit assignments were made to pilots in advance of actual spraying to afford them an opportunity to determine the most efficient flight pattern to follow. In most instances the pilots would make a "dry run" over a newly assigned unit before applying any spray. That these flight patterns were satisfactory was evidenced by the effective coverage obtained. It must be recognized that pilots cannot gridiron an area without some error, especially in the rugged topography which characterized the tussock moth zone of infestation. The overlap from the assigned swath width apparently aided considerably in obtaining uniform

spray coverage from the slight deviations in flight lines which undoubtedly occurred.

The acreage of each unit was checked against the volume of spray used. Although there were some "unders and overs" the close relationship which existed in the final results showed that this phase of the operation was given careful attention by the pilots.

One of the most important factors governing the success of the aerial spraying was wind velocity. Light cross winds provide maximum spray dispersal, but "no wind" days provide optimum flying conditions. From daylight (3:30 a.m.) to 8:00 or 9:00 a.m. proved to be the best flying hours. The calm, cool air usually found at that time permits planes to be more easily controlled, which provides for better performance and materially reduces the hazard of the work.

Morning spraying started about 4 a.m., and usually continued until such time as the morning wind increased to more than 8 miles per hour. On days when there was no wind, flying continued until thermal activity made the work dangerous, or the pilots became tired. There were only a few days when morning flights continued after 9 a.m. Fortunately, it was found that some evening spraying was feasible. On such days flying would start about 4 p.m. and continue as long as sufficient light remained, usually until 7:30 p.m.

From May 20 to July 2, there were only 3 days when spraying could have continued throughout the day. Of the 30 days that spraying was conducted only 8 of them permitted evening work. No spraying was conducted during winds of 8 or more miles per hour and a 6-hour maximum wind would have been much better as the limiting point. Advantage was taken of every hour of spraying weather except toward the end of the operation when spray deliveries became irregular. Spraying was stopped at least 1 hour before rain and not resumed until the foliage had dried.

The tabulation given below summarizes the performance of the different planes used on this project. Although these figures are significant for this operation, they do not tell a final story, as all factors were not considered. The flight time, or distance from airfield to the spray units, is an important item which would have a direct bearing upon such an analysis. Due to the fact that planes carrying the largest loads were given the longest ferry flights, this factor would rather seriously affect the volume of spray dispersed.

Plane and number	Gallons of spray used	Total trips	Gallons per trip	Average time per trip (minutes)	Gallons of spray per hour
Stearman 49255	20,212	311	64.99	16.9	230.3
" 58700	20,157	307	65.66	16.3	241.4
" 58706	12,046	163	73.90	18.2	243.5
" 73743	20,987	305	68.80	16.1	257.5
Total for Stearmans	73,402	1,086	--	--	--
Average for Stearmans	--	--	67.59	16.7	243.0
Travelair 9842	14,106	92	153.33	17.5	522.4
" 411N	33,664	182	184.97	22.0	504.2
Total for Travelairs	47,770	274	--	--	--
Average for Travelairs	--	--	174.34	20.5	510.1
Stinson 216W	30,843	230	134.10	19.8	405.3
Fairchild 719708	34,826	180	193.48	24.3	477.8
TOTAL SMALL PLANES	186,841	1,770	--	--	--
AVERAGE SMALL PLANES	--	--	105.35	18.4	343.2
Douglas C-47	107,510	108	995.46	57.9	1,031.2
Ford Tri-Motor	48,257	121	398.81	57.1	418.7
" " "	48,270	121	398.92	58.2	411.0
TOTAL LARGE PLANES	204,037	350	--	--	--
AVERAGE LARGE PLANES	--	--	582.96	57.7	605.5
TOTAL ALL PLANES	390,878	2,120	--	--	--
AVERAGE ALL PLANES	--	--	184.37	24.9	443.5

In considering the remarkably uniform spray coverage, too much credit cannot be given to the good judgment and outstanding flying performances of the pilots. The large number of planes in the air at one time, the speed with which the spray was applied - usually 25,000 gallons (or 25,000 acres) per hour - and the extremely rugged terrain of the north Idaho country made it impossible to set up flight markers of any kind to aid them in working out their spray patterns. Time and time again, however, a check of each pilot's flying made from the air and from the ground showed that, once his flight pattern was determined for the unit assigned to him, he could be depended upon to cover it uniformly and with the desired gallonage.

The efficiency of the ground crews in reloading and servicing planes, usually one every 3 to 5 minutes, and the precision flying performances of the pilots drew constant praise and admiration from local residents and the project staff alike. There were three accidents involving the spray planes - one ground loop and two forced crash landings, one due to motor failure and the other to down drafts at the head of a small canyon. Fortunately, the pilots suffered only slight injuries.

Checking Spray Coverage

Checking the spray coverage of each airplane was one of the important activities of the project. The information gleaned from this work determined whether the spray was being dispersed adequately. The performance of the spray equipment in regulating droplet size and quantity as well as the uniformity of distribution was checked from the ground by means of small glass plates. The aerial spraying contractors received payment for their work only upon the opinion of the checking crews as to whether flight units or blocks of units had received satisfactory coverage.

Checking the spray coverage was handled by a 12-man crew working under the supervision of the Bureau of Entomology and Plant Quarantine. These men usually worked alone so that each man checked one plane during each spray period. Working in close cooperation with the spray pilots, each man determined the location of his check for the next spray period. This depended greatly upon its accessibility, a factor which made this work difficult because of the scarcity or absence of roads throughout much of the sprayed area.

Once "on location," the checker laid out a string of 4 x 4-inch glass plates from 20 to 50 feet apart on a line perpendicular to the expected lines of flight. The plates were usually placed on small squares of newspaper to enable them to be found when picked up later. Occasionally they were spotted by the pilot, too, who immediately entered into the spirit of things by making sure all the plates were covered, which they most certainly were.

In about an hour after the spray droplets had been deposited they had sufficiently dried to permit them to be collected and sent to project headquarters in Moscow for analysis along with certain data pertaining to the check. (See Appendix Form 5 and plate X) This usually brought out any discrepancies in the way the spray was being applied. This information with suggestions for correcting the apparent causes was relayed back to the checking foreman, who then worked with the contractor's staff to see that they were carried out before the ensuing spray period.

Some disadvantages in this method of checking soon became apparent which might be overcome in future projects. In a number of cases, checkers were left out in remote mountainous locations unaware that spraying operations, permitted only on an hour-by-hour basis because of marginal weather, had been canceled. Some pilots who had spotted the checker managed to convey this news by dipping the wings on the last run, thus saving the checker hours of fruitless waiting. Then, too, the matter of cleaning the spray deposit from the plates by immersion in xylene proved expensive and laborious in addition to creating a bad fire hazard. With each checker sending in 36 plates once and sometimes twice a day during spraying operations, their cleaning and return to the field became a cumbersome task.

Considerable checking of spraying was done from the air. Most of this work was performed by Mr. Arthur Gieser, Bureau of Entomology and Plant Quarantine spray pilot, from a bureau plane. In this manner the flight patterns and performance of the different pilots and planes could be quite accurately checked. This method of checking, by an experienced spraying pilot, was an important addition to the checking organization of the

project. Mr. Gieser was also of great assistance in helping the spray pilots in many details of spray plane operation.

RESULTS OF SPRAYING

Effect Upon Tussock Moth Infestation

The primary objective of the 1947 aerial spraying program was to destroy as much of the 1947 tussock moth population as possible before it could cause a repetition of the severe defoliation of fir forests which occurred in 1946. This objective was attained. The success of the spray program was far greater than had been anticipated. Instead of the 75 percent of the tussock moth population which it was hoped would succumb to the effects of the DDT, checking crews found close to 100 percent mortality everywhere in the treated area. Procedures to check the degree of mortality based upon the assumption that there would be some caterpillar survival were abandoned. There simply were no living caterpillars apparent in the treated area.

This unexpected effectiveness of the DDT solution was believed to have been achieved because the unusually rapid coverage of the infested area by the spraying operations permitted the spray to be directed against the early caterpillar instars, the only tussock moth stages present in the area at the time. Studies have shown that this period in the development of the tussock moth is most susceptible to the lethal effect of the insecticide formula used in this project. The ground was strewn by countless thousands of small tussock moth caterpillars which apparently dropped from the trees during the first 24 hours following the application of the spray.

Benefits directly attributed to the spraying are largely the saving of fir forests from damage or complete killing from tussock moth attacks in 1947 and the apparent reduction of the moth infestation from epidemic to sub-normal status. It is estimated that 1½ billion board feet of merchantable poles and sawlogs, valued at $4,328,000, were saved from serious defoliation in 1947 as a result of the spraying. It is believed that an additional 1.2 billion board feet immediately adjoining the sprayed area were also saved from defoliation which might have occurred in 1947 had spraying in the infested area not been carried out.

The spraying also prevented continued defoliation, and hence complete killing, of dense fir forests on 140,000 acres (see figure 2) which had been very severely defoliated in 1946 and re-infested in 1947. The saving of this timber was especially gratifying since it comprises some of the most promising farm forests in the Inland Empire.

The saving of the above timber is also indirectly beneficial since it helps to maintain a natural resource upon which a substantial part of the economy of north Idaho is based. It also was of direct and very material benefit in holding down the forest fire hazard which would have resulted from the accumulation of additional heavily defoliated and dead timber.

The spraying practically wiped out a widespread tussock moth infestation which had remained in epidemic status for 2 years. The lethal effect of the spray was so great that not enough tussock moth survival occurred to permit the re-establishment of the infestation in the sprayed area for at least a year or two. Using past experience as a guide, it is doubtful if

another tussock moth infestation will appear within a considerably longer period.

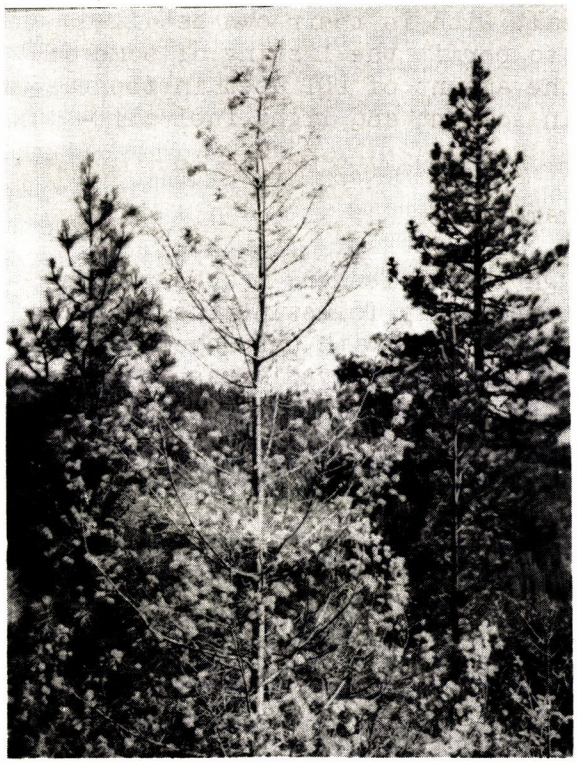


Figure 2. Top of a Douglas-fir tree heavily defoliated by the tussock moth in 1946. Note the 1947 needle growth - enough, perhaps, to carry the tree over to eventual recovery. Even this, too, was threatened by the 1947 brood of tussock moth caterpillars. Except for timely spraying this meager foliage would have been destroyed, making the death of the tree a practical certainty. This tree is typical of trees making up the major forest cover on 140,000 acres in the Moscow Mountain and other areas within the zone of infestation. Trees in the background are ponderosa pines and not affected by the tussock moth. (1277, Johnson)

Further assurance of this comes from the fact that several infestations of tussock moth which developed outside the sprayed area in 1947 were wiped out by the combined action of a virus disease and insect parasites in August. This is described in more detail in a following section of this report. Unfortunately, these natural control factors, even if they could have been foreseen, reached their maximum effectiveness too late in the season to have achieved the same results as the spray program did.

Effect Upon Wildlife

The possible effect of the DDT spray mixture upon domestic and wild birds and animals concerned many residents of the infestation zone during the preliminary planning of the tussock moth project. The domestic animals were dismissed from consideration since most of these were in nonforested areas which were not sprayed. The few cattle grazing in forest lands earmarked for spraying were known by previous study to be immune to any adverse effects of the DDT formula which was to be used. Domestic bees were known to be susceptible to the lethal action of the spray, and provisions were made in the project plans to warn all beekeepers in range of the spray so that they could take action to protect their colonies on the day spraying was to be done in their immediate vicinity.

The effect on wildlife of DDT sprays for forest work was still not too well known when the tussock moth project was approved. The spraying of such a vast wilderness provided an excellent opportunity for further study along this line. The United States Fish and Wildlife Service took advantage of

this opportunity by assigning Mr. M. G. Hanavan, aquatic biologist, and Mr. Lowell Adams, specialist on mammals, to study the effect of the DDT spray on fish and on birds and mammals, respectively.

The findings of these two men will be dealt with in their own detailed reports, but they have been kind enough to permit the listing of some of their conclusions in this report. For the amount of DDT used in the tussock moth operation - 1 pound per acre in solvent and light fuel oil - these men found that:

1. There was no appreciable effect on mammals.

2. Bird life appeared to be normal though insect feeders probably were forced to a change of locality or diet temporarily following the spraying. The sprayed areas were interspersed in many places with unsprayed areas so that any killing off of native insect life in the sprayed areas was offset by normal insect life in the unsprayed areas.

3. Rainbow, eastern brook and cutthroat trout in the 40 streams in the treated area where these species occurred suffered no apparent ill-effects. Contents of trout stomachs indicated, however, a 50 percent reduction in available food - largely in aerial insects and riffle forms - and a change of diet to include more crustacean forms.

4. Crayfish mortality in sprayed streams was heavy.

5. Stream sections which suffered heavy mortality to invertebrate life soon were marked by a luxuriant growth of algae which completely blanketed many of the riffles.

6. Insect larvae and nymphs were virtually eliminated from the riffle fauna by the action of the spray.

It is indeed gratifying to learn that it is possible to spray large forest tracts with DDT dosages sufficient to control major insect pests without causing harm to the non-insect fauna. In future operations the evidence just presented indicates that even the slight harmful effects which were produced could perhaps be eliminated if the spray pilots were instructed not to use farmhouses or yards for turning points, to avoid using the same routes to and from the landing field if possible, and not to fly directly along streams but to one side.

DEVELOPMENT OF INFESTATIONS OUTSIDE THE TREATED AREA

By Philip C. Johnson, Entomologist

Idaho State Forester Stanton G. Ready, in establishing a "zone of infestation" defining the limits of the aerial spray program in the Moscow, Idaho, area, included all areas where tussock moth infestations were known to exist. It was not until after the spraying was completed that several new outbreaks were discovered outside the perimeter of the infestation zone by Bureau of Entomology and Plant Quarantine scouting parties and by foresters of the Clearwater Forest Protective Association and the U. S. Forest Service. (See map, plate XIII)

As the 1947 summer progressed these infestations, as well as certain others subsequently located, were studied by the bureau to record their development and to watch for any epidemic tendencies. By means of aerial reconnaissance and by intensive and extensive ground examinations the location and extent of each infestation center was determined and the amount of damage ascertained. Details of the development of the various stages of the tussock moth were obtained from periodic observations at key points as the season progressed. In addition, effects of parasites upon the moth infestations were studied from material reared at the bureau's insect laboratory at Coeur d'Alene, Idaho. Information gleaned from these various activities has made it possible to determine the trend of the infestations and to evaluate their importance in the discussion which follows.

Distribution of Outside Infestations

In the northern Idaho-northeastern Washington section there were two fairly large areas of active tussock moth infestation which received no control treatment in 1947. One of these, near Orofino, Clearwater County, Idaho, covered approximately 20,000 acres of grand fir stands left as a result of pine cutting operations some years ago. In this area, which lies between the towns of Orofino, Headquarters and Weippe, the infestation was more or less spotty in a stand which was quite uniformly composed of large medium-dense reproduction and poles.

The second area was located near Colville in Stevens County, Washington. Besides its choice of Douglas-fir as a host, this infestation differed from the Orofino one in that it did not occur as uniformly over the infested area, but rather as a series of well-defined and distinctly separated centers. Furthermore, the Douglas-fir stands were younger and much denser than the infested grand fir stands in the Orofino area. At least a dozen separate infestation centers, totaling about 10,000 acres, were located between the Columbia and Colville Rivers near the towns of Gifford, Rice, Addy, Colville and Kettle Falls.

Development of the Natural Infestations

It should be pointed out that the Orofino and Colville infestations cannot be compared to the Moscow infestation which was treated by aerial spraying in June. Whereas the infestation in the latter area was highly epidemic, resulting from several years' build-up, the Orofino and Colville outbreaks were in their initial stages. If visible damage is used as a criterion, it might be said that these outbreaks began early in the summer of 1947. Actually, however, the tussock moth population was building up in these areas in 1946 since numerous egg masses were laid in the fall of that year. The question as to whether the outbreaks developed "in place," as seems to be the case at Colville, or by infiltration from nearby epidemic infestations, or both, as it appeared at Orofino, cannot be answered conclusively from the facts at hand.

Life History

Despite the fact that the new outbreaks at Orofino and Colville were in their incipient stages, a heavy population of tussock moth caterpillars was produced from eggs which had been deposited in September 1946. As may be seen in the life history diagram (plate XIV), these eggs began hatching late in May of this year.

The caterpillars appeared to have developed normally and to have reached their full growth the latter part of July at Colville and early in August in the Orofino area. At this point, however, the caterpillars suddenly became sickly and bedraggled in appearance and began dying in great numbers. Many of their bodies were draped limply over twigs in grotesque fashion or hung in inanimate suspension on the trunks of the trees. Many caterpillars were clustered about the bases of infested trees (plate XV), having dropped out of the trees either in preparation for pupation or because of their sickly condition.

Mortality From Virus Disease

Ailing caterpillars collected by Mr. William W. Teter, assisting the writer in field observations, were determined by Dr. Edward A. Steinhaus, assistant professor of Insect Pathology, University of California, to have succumbed to polyhedrosus, a disease caused by a polyhedral virus. So conclusive was the action of the disease that practically all the living caterpillars of the tussock moth were killed with dramatic suddenness. This was especially so in the Colville area. In the Orofino area the caterpillar mortality resulting from the disease was less, but still a potent factor in completely halting further development of the 1947 tussock moth broods.

Mortality From Parasites

The virus disease was not the sole factor in curbing the 1947 infestations in these two areas, however. Soon after the caterpillars began their growth it became evident that they were becoming parasitized in increasing numbers, particularly in the Orofino area. Caterpillars and pupae collected from both this and the Colville area were placed in rearing at the Coeur d'Alene Forest Insect Laboratory at intervals during July and August. Normally these could have been reared through to new adult moths with very little mortality. In contrast to this the reared material showed the following results:

Stage	Number collected	Number of adult moths produced	Mortality percent
Caterpillars	695	57	91.8
Pupae	839	2	99.8

While the above mortality was due principally to a tachinid and several hymenopterous parasites, contamination by the virus disease undoubtedly accounted for some of the mortality. It is believed that the mortality from parasites alone, however, would have been great enough to have effectively stopped most of the tussock moth infestations by the time normal pupation would have occurred in August.

As a result of the combined action of the virus disease and parasites all development of the tussock moth infestations in the Colville and Orofino areas ceased the latter part of August. Very few pupae were formed and these were heavily parasitized. No adult moths were observed in the field and a concerted effort to locate new egg masses during September failed to reveal any.

Damage From 1947 Infestations

It is doubtful if the 1947 tussock moth infestations in the Colville and Orofino areas resulted in any trees being defoliated beyond the point of recovery. Defoliation of grand fir in the Orofino area was light enough in many cases to escape casual notice. Damage to the Douglas-fir in the Colville area seemed somewhat heavier, resulting for the most part in more complete defoliation of the upper crowns. A slowing up of growth and some stem deformity will undoubtedly follow the defoliation. There should not be much danger of subsequent Douglas-fir bark beetle attacks in the Colville area because of the young age of the defoliated trees.

Possibility of Continued Infestations

The 1947 tussock moth infestations in the Colville and Orofino areas appear to have been completely wiped out in August due to the effects of the virus disease and parasites. The complete absence of 1947 egg masses in these two areas is reasonable assurance that the infestations have definitely been halted.

PROJECT ADMINISTRATION

The cooperative nature of the tussock moth project might have introduced serious problems in its administration had not all interested agencies agreed to permit one of their members to assume the responsibility for carrying out the program. In accepting this responsibility the United States Forest Service drew upon its widespread experience in handling forest projects of this size. Regional Forester P. D. Hanson of Forest Service Region One at Missoula, Montana, under whose jurisdiction the tussock moth project was to be conducted, named Assistant Regional Forester Paul H. Roberts as project leader. Mr. Jack Jost of this same office was named assistant project leader.

These men had the task of setting the project in motion, of setting up administrative and fiscal procedures, and of coordinating the various activities within the project. These activities were channeled under subordinate officers as shown in the organization chart for the project (Appendix Form 6). Detailed instructions and procedures were established for each activity by these officers and the project leaders. Many of these have been described in general in the body of this report.

These activities, once established, proceeded fairly smoothly within themselves, but they were so interrelated that the disrupting of any one affected many of the others. Once spraying had started every activity was conducted so that it would not contribute to delaying the spraying at any time spraying weather was good.

The project leaders handled all matters between the project and the spraying contractors. These had to do mostly with providing certain services to the contractor, i.e., air-strip maintenance, weather reports, communications, spray solution, aerial photographs, maps, spray checking and other technical information as requested. A procedure for paying the contractors for work accomplished was also set up. This required such information as provided for in Appendix Forms 7 and 8 which was obtained by the airfield supervisors.

The administrative officers were also charged with seeing that all contracts and agreements pertaining to the operation of the project were carried out, that funds were accounted for, and that a report of the work done and its results is made available to all cooperators.

SPECIFICATIONS FOR AIRPLANE SPRAY, 12 PERCENT DDT, FOR TUSSOCK MOTH CONTROL

A. APPLICABLE SPECIFICATIONS

A-1. The following specifications shall form a part of the purchase description:

A-1a. Joint Army and Navy Specification JAN - D - 56A Dichlorodiphenyltrichloroethane (DDT).

A-1b. U. S. Army Specification 2 - 102c - Oil, fuel, Diesel.

A-1c. I.C.C. Specification 17E - I.C.C. Regulation. Transportation of Explosives and Other Articles by Freight.

B. TYPE

This purchase description covers one type and grade of insecticide, Airplane Spray, 12% DDT.

C. MATERIAL AND WORKMANSHIP

C-1. The material shall conform in all respects to the specifications listed in Section A and as hereinafter specified.

C-2. The material shall be mixed by suitable processes. The finished material shall be homogeneous, clean, and free of all insoluble matter.

D. GENERAL REQUIREMENTS

D-1. The insecticide shall consist of one (1) pound of DDT dissolved in sufficient mixed solvent to make one gallon of finished spray.

D-2. The mixed solvent shall consist of the following ingredients by volume at 68 degrees F.:

Auxiliary hydrocarbon solvent	15 parts
Oil, fuel, Diesel Type A	85 parts

E. DETAILED REQUIREMENTS

E-1. Dichlorodiphenyltrichloroethane (DDT). - The DDT shall conform to Grade B of the Joint Army-Navy Specification JAN - D - 56A.

E-2. Oil, Fuel, Diesel. - The Diesel oil shall conform to Grade A of U. S. Army Specification 2 - 102c.

E-3. Auxiliary Solvent. - The auxiliary solvent shall consist principally of hydrocarbons with the following physical characteristics:

Flash point (Cleveland Open Cup)	200° F. min.
Distillation range	
Initial boiling point not less than	375° F.
Final boiling point not greater than	700° F.
Viscosity, Saybolt Universal at 100° F.	30 to 55 seconds
DDT solubility, at 30° C.	35% by weight min.

F. PACKAGING

To be delivered in tank cars.

TYPES OF PLANES AND SPRAYING EQUIPMENT

Douglas C-47. This plane carried approximately 1,000 gallons of spray, in four tanks within the fuselage. Two of these tanks were of 285-gallon capacity while the other two carried 244 gallons. They were connected by 2-inch aluminum tubings and ½-inch vent lines. An exhaust-engine-driven vacuum pump connected to these interconnected tubes maintained a constant tank pressure of 3 pounds per square inch. The variation of the rate of flow between a full and rapidly emptying tank amounted to less than 8 percent. A specially designed gravity-flow outlet valve permitted the flow of spray mixture to be regulated from a few gallons to a maximum of 120 gallons per minute. The spray passed through this valve to a venturi type of nozzle located under the fuselage which broke the liquid into small droplets of a satisfactory size. This venturi was 48 inches wide and composed of three 2-inch streamlined tubes spaced 1 inch apart. The upper and lower tubes had but one row of 1/8-inch holes ½ inch apart pointing downward and upward respectively, while the middle tube had holes on both the upper and lower sides. Air suction around the venturi tubes developed a 2-pound negative pressure which, with the motor-driven vacuum pump, created a total of 5-pounds-per-square-inch pressure on the spray within the tanks. Pressure of the spray mixture remained constant.

Ford Tri-Motors. These planes carried two 215-gallon aluminum tanks within the fuselage. These were connected at the bottom with a 2-inch pipe, with a lead from the interconnecting tee to the pump. Spray fluid was drawn from these tanks with air-cooled, gasoline-motor-driven centrifugal pumps capable of delivering 60 gallons per minute. Two types of pumps were used with equal satisfaction. One of these was an APCO, HH4, BF centrifugal (two stage) pump made by the Aurora Pump Company, and the other a Forester centrifugal 2BW4 pump. Two motors were used to drive these pumps, a Briggs and Stanton Motor ZZ and a Wisconsin AKS engine. The power of these motors, which was 7 and 5 h.p., respectively, was sufficient to maintain a delivery of 60 gallons per minute from both pumps. From the pumps the spray flowed through a 2-inch oil-proof hose which led through the wings and down to the spray booms through an inspection plate. The booms were mounted on the lower surface of each wing and were made of 1-inch tubing, with 18 evenly spaced 1/8-inch holes. The holes pointed backward at an angle of 45 degrees.

Single-Motored Planes. These included Stearman, Fairchild, Travelair 6000, and Stinson SM7A planes. These smaller planes were equipped with tanks varying from 75 gallons for the Stearmans to 225 gallons for the Fairchild. Stinsons carried 150 gallons of spray and the Travelairs 200 gallons. Spray was drawn from these tanks with 1-inch Simplex centrifugal pumps located between the landing gear struts and powered by wind-driven, four- and six-blade propellers. With planes moving at a speed of 80 to 90 miles per hour these pumps operated at approximately 3,000 r.p.m. This speed maintained an operating nozzle pressure of approximately 75 pounds which delivered some 27 gallons per minute. Spray passed from the pumps to spray booms mounted below the wings. These booms were constructed from tapered 1½- to 5/8-inch thin-wall steel conduit tube. They were 15 feet long on the Stearmans and 17 feet on the Stinson, Travelairs and Fairchild. Friend spray nozzles were mounted at 14-inch intervals on the 15-foot booms, and at 17-inch intervals on the longer ones. These nozzles were equipped with spring valves set to release at 10 pounds pressure which helped to prevent dripping when the flow of spray to the booms was shut off.

APPENDIX FORM 1

Tussock Moth
Control Project

PRE-CONTROL SURVEY DATA RECORD

Date 4-18-47
Name Wilson
Age Repro. & 40-69yr

Area - T. 41 N. - R. 3W. Section 32

Description of area

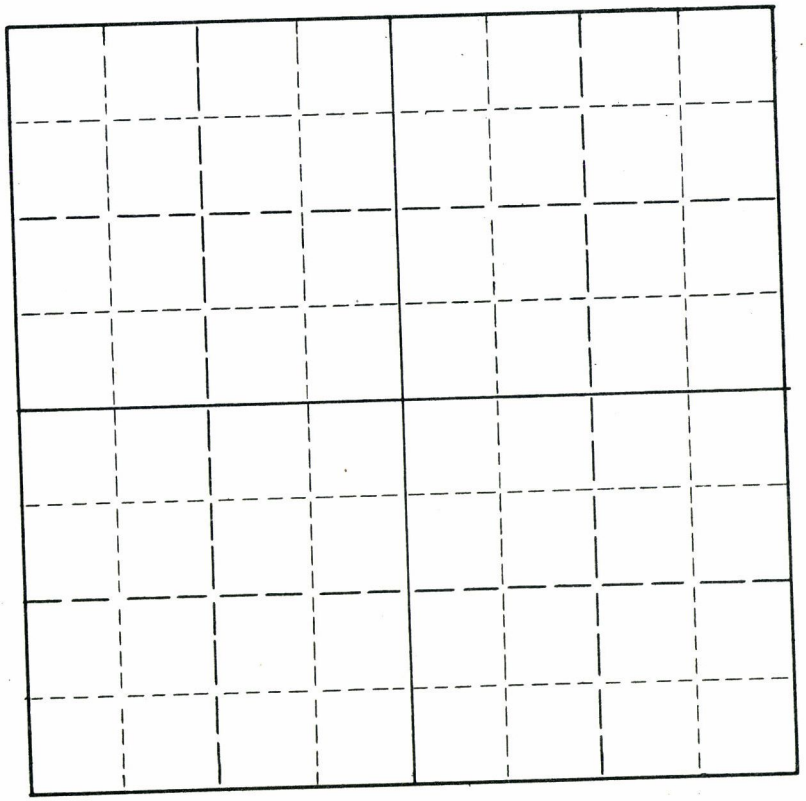
Open stand PP in north half of section with variable amounts of DF. South half more heavily stocked with L-DF poles.

Stocking

Larch-Douglas-fir poles comprise 40-69% of volume in south half of section. North half of section more or less open ponderosa pine with Douglas-fir. Entire section selectively cut over.

Description of infestation

Defoliation general over entire section, ranging from light in the scattered DF in the open PP-DF mixture to medium where DF increased in percent of volume and in density. Heaviest defoliation on north-facing slopes, especially where over mature WF comprises part of the stand volume.



APPENDIX FORM 2

Forecast No. 70
Released at 3 p.m. 6-28-47

Tussock Moth Control Project
Moscow, Idaho
June 28, 1947

FORECAST FOR THE PERIOD SUNUP TO SUNSET JUNE 29, 1947, FOR AERIAL SPRAYING OPERATIONS, TUSSOCK MOTH CONTROL PROJECT:

1. Weather: Scattered clouds becoming broken in afternoon.

2. Thermal activity: None sunup to 8 a.m.; mild thereafter becoming moderate in late afternoon.

3. Wind flow aloft, 5,000' to 8,000' MSL: Northerly 5-10 m.p.h.

4. Remarks: A storm is approaching our northwest coast. This may affect our weather late Sunday or early Monday.

5. Wind estimates at field stations:

(a) Station	(b) Daybreak to 8 a.m.	(c) 8 a.m. to 10 a.m.	(d) 10 a.m. to 5 p.m.	(e) 5 p.m. to nightfall
Moscow	E 0-5 mph	Vrbl 0-5 mph	W 5-10 mph	0-5 mph
Princeton	E 0-5 mph	Vrbl 0-5 mph	W 5-10 mph	0-5 mph
Elk River	Vrbl 0-5	Vrbl 0-5 mph	SW 0-5 mph	Vrbl 0-5 mph
Laird Park	NE 0-5 mph	Vrbl 0-5 mph	SW 3-8 mph	Vrbl 0-5 mph
Hoodoo	W 0-5 mph	W 5-8 mph	W 5-10 mph	W 5-8 mph

C. E. Syverson
Forecaster

M-1075-R1 APPENDIX FORM 3

S
CONTROL
Insect
Tussock Moth

DAILY REPORT OF AIRPLANE TREATMENT CHECK

Date 6/17/47 Reported by Wilson

Section 8-9-16-17 Township 41N Range 2E

Flight unit - name C-47

Number of plates put out 36

Distance between plates 50'

Position of plates in relation to line of flight diagonally

Time plates were placed 5:30 a.m.

Weather and ground conditions Clear, no wind

Time plates were picked up 10:30 a.m.

Number of negative plates and action taken ---

Were airplane runs checked? Yes X No

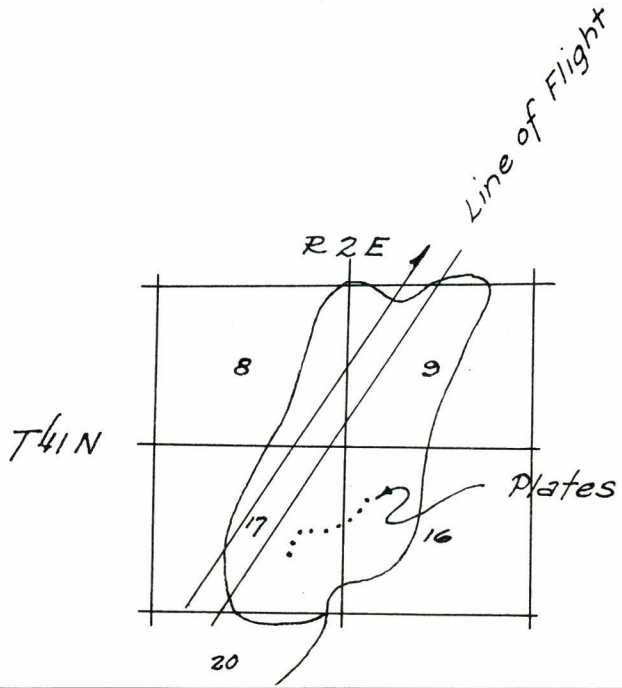
Approximate width of runs 400-500'

Direction of flight NE - SW

Approximate height of plane over trees 100-200'

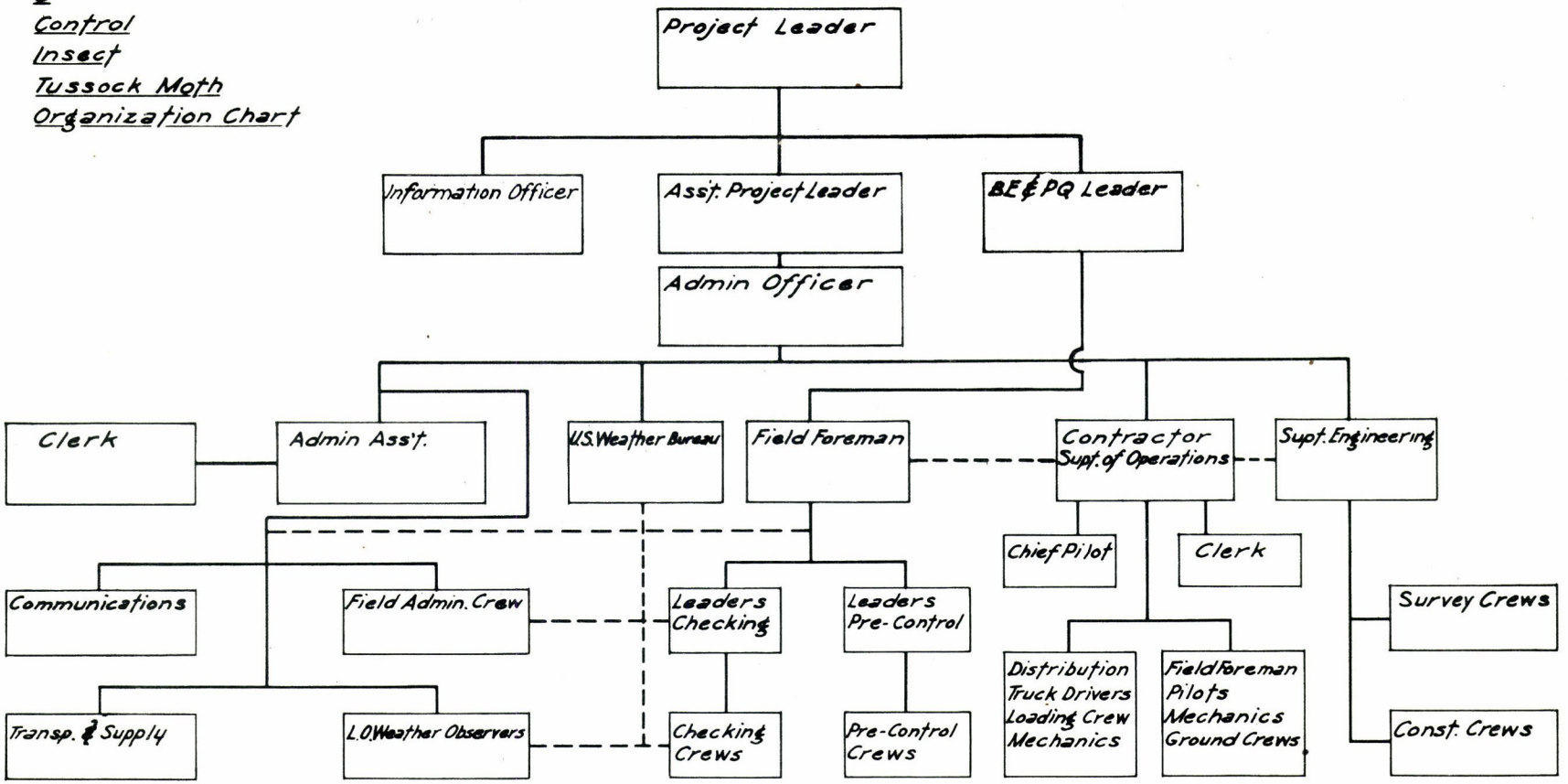
Remarks (should include any unusual conditions noted):

I arrived in vicinity at 4:40 a.m. at which time first load was being sprayed.
Second load arrived at 5:50 a.m.
Third load arrived at 7:10 a.m.
Very good coverage.



S

Control
Insect
Tussock Moth
Organization Chart



LEGEND

——— Indicates Control Channels

– – – – – – " Close Liaison

APPENDIX FORM 4

S
CONTROL
Insect
Tussock Moth

DAILY FLIGHT RECORD AIRPLANE NO. _____

Type plane _____ MPH _____ Pilot _____

Spray capacity _____ (gallons) Swath width _____ (feet) Month _____

Flight unit: Name _____ No. acres in unit ____ Dosage per acre ___

Date	Number trips made	Gallons spray dispensed	Number acres sprayed	Total flying time	Total accumulated acres sprayed	Remarks
Total						

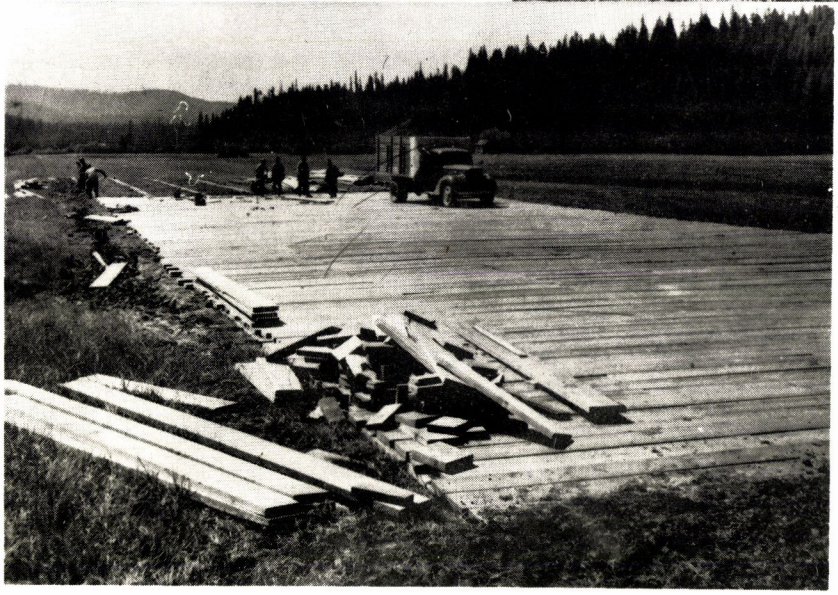
Sheet _____ of _____

PLATE I

AIRSTRIP CONSTRUCTION

Aerial view of the temporary tussock moth project air strip built near Laird Park, Latah County, Idaho. Air strips built by the project were usually located in parts of newly seeded grain fields leased from the farmers. (1253, Bloom)

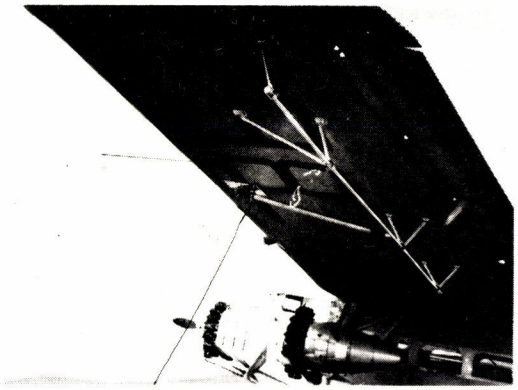
Temporary air strips like this one near Troy, Idaho, were hastily constructed by heavy earth-moving equipment sent by the U. S. Forest Service from its Missoula, Montana, headquarters. (1151, Johnson)



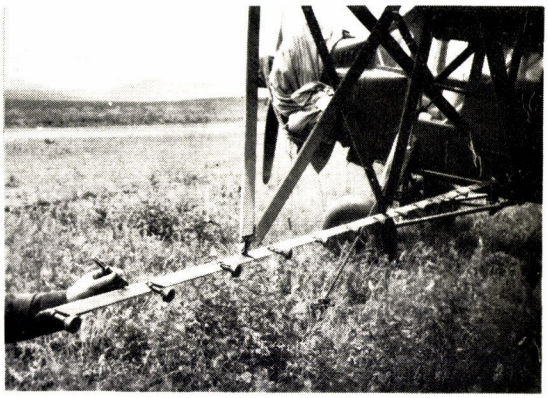
The temporary nature of the air strips prevented their use at times during wet weather. While most of the strips dried quickly following rainstorms, a high water table causing boggy ground made planking of a portion of the busy strip at Laird Park a necessity. (1231, Johnson)

PLATE II

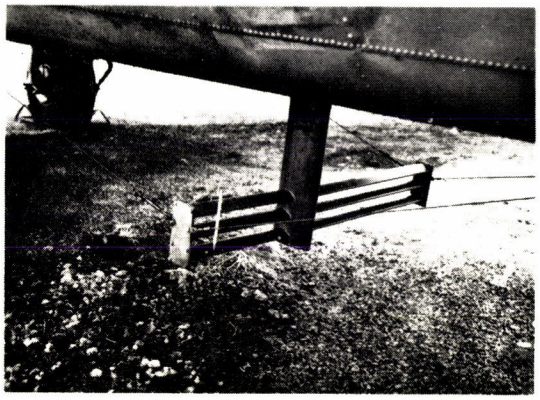
AERIAL SPRAYING EQUIPMENT



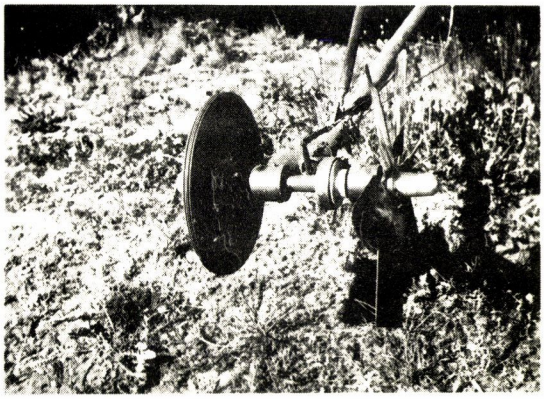
Detail of the boom-type spray nozzles used by the Ford tri-motor spray planes of the Johnson Flying Service. (1222, Johnson)



Multiple-nozzle spray boom developed by the Central Aircraft Company. These were fitted to all single-motored planes used on the project. (1225, Johnson)



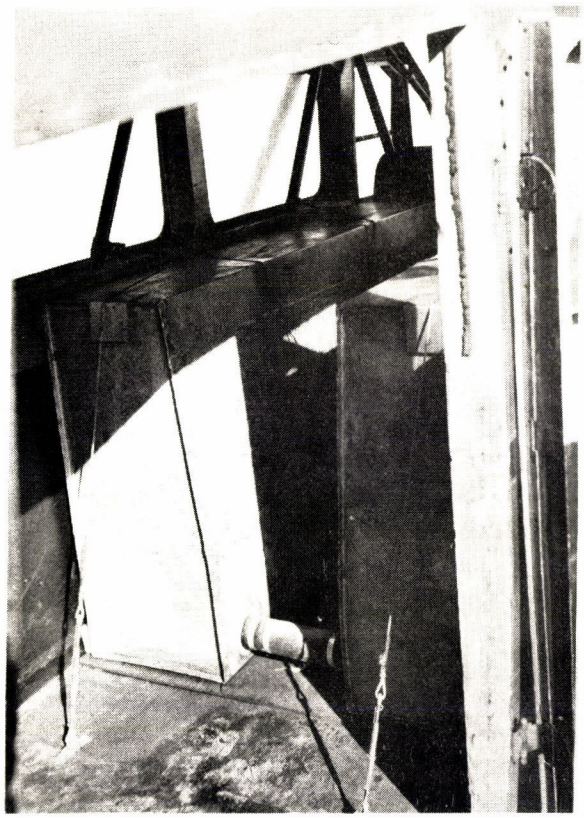
Venturi spray nozzle (note pencil for comparative size) mounted under the fuselage of the Douglas C-47 spray plane. Each of the three horizontal tubes is of airfoil design to cut down air resistance and to secure atomizing effect as the spray solution leaves the nozzle openings. (1226, Johnson)



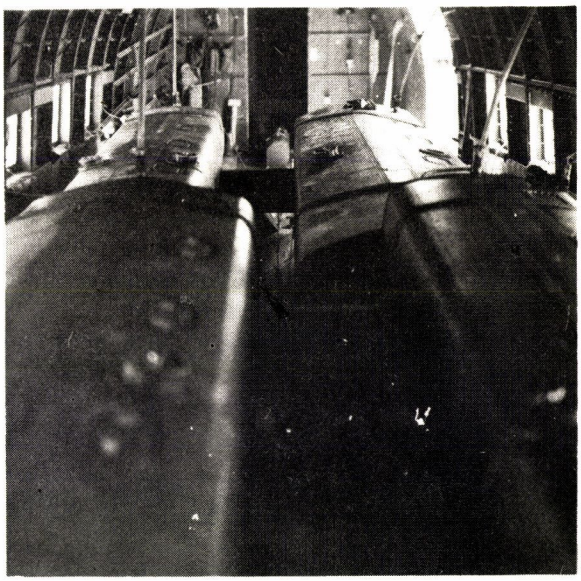
Wind-driven spinner disc spray nozzle used on the Bureau of Entomology and Plant Quarantine's White Standard spray plane. The spray mixture is fed to the perimeter of the discs by centrifugal force and then finely atomized by the action of the plane's air wash. (1223, Johnson)

PLATE III

AERIAL SPRAYING EQUIPMENT



One-hundred-gallon-capacity spray mixture tanks installed in a Travelair spray plane. (1244, Johnson)



Interior of the Douglas C-47 spray plane showing the installation of the four spray solution tanks. (1247, Bloom)

Air-driven centrifugal pumps used on the single-motored planes to maintain a small pressure in the spray mixture tanks and distributing system. To the right center of the picture may be seen two emergency dump valves beneath the spray mixture tanks by means of which the tanks may be quickly emptied. (1224, Johnson)

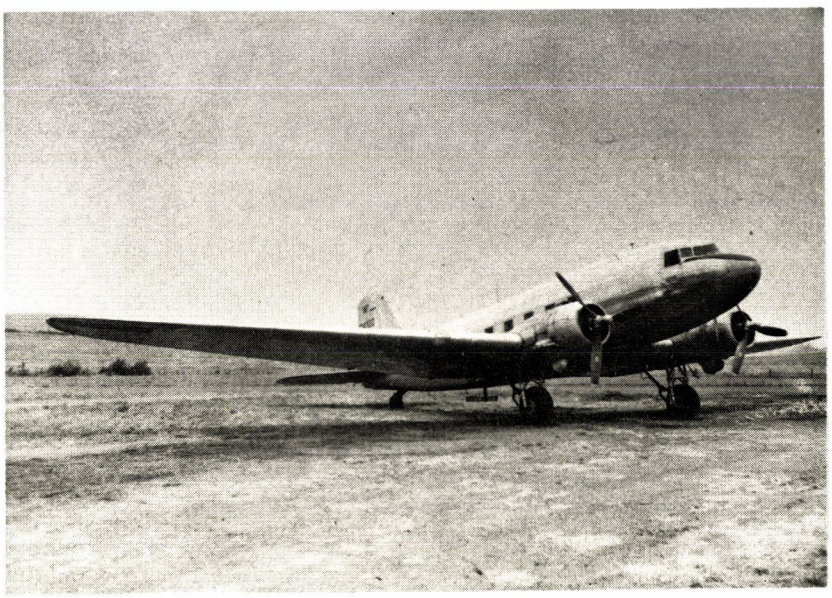
PLATE IV

AERIAL SPRAYING EQUIPMENT

The Stearman (above, 1191, Bloom) and the Travelair (below, 1188, Bloom) spray planes are typical of eight single-motored airplanes used on the tussock moth project by Central Aircraft Company of Yakima, Washington.

PLATE V

AERIAL SPRAYING EQUIPMENT



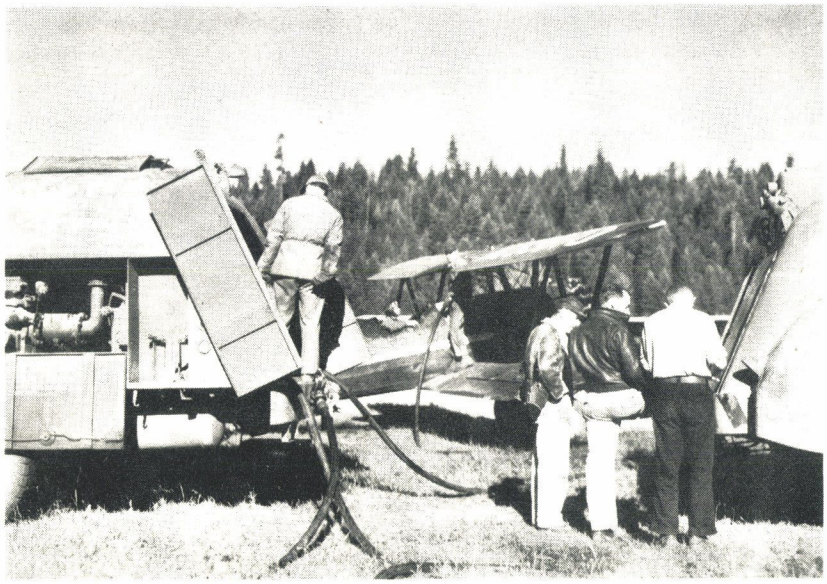
Ford tri-motor (above, 1227, Johnson) and Douglas C-47 (lower, 1229, Johnson) spray planes used by Johnson Air Service of Missoula, Montana. Despite their great size they turned in very capable performances on the tussock moth project.

PLATE VI

SPRAY SUPPLY AND TRANSPORTATION

Samples of the spray mixture were taken from each incoming tank car and sent to the Bureau of Entomology and Plant Quarantine, Division of Insecticide Investigations for DDT content analysis. (1243, Johnson)

Transferring DDT-oil spray mixture from railroad tank cars to U. S. Army Air Force semi-trailer tank trucks at the Moscow, Idaho, railhead. Note jeep with fire control equipment. (1241, Johnson)



An integral part of the spray tank trucks were powered pumps which permitted the spray mixture to be pumped directly from the trucks to the spray plane tanks. (1189, Bloom)

PLATE VII

AERIAL SPRAYING

Spray planes in action; a Stearman (above, 1171, Johnson) and a Ford tri-motor (below, 1175, Johnson). The characteristic swirling motion of the spray is clearly discernible in the lower photograph.

PLATE VIII

AERIAL SPRAYING

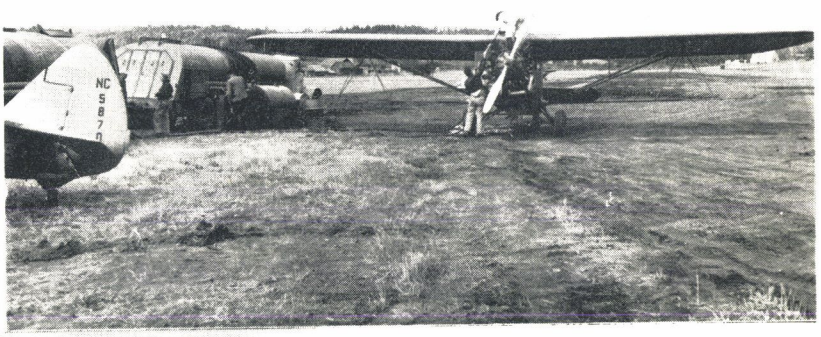
The Douglas C-47 (above, 1177, Johnson) and a Ford tri-motor (below, 1202, Johnson) are shown here spraying extensive fir forests east of Bovill, Idaho, fully 50 miles from their base. Approximately 650 square miles of this type of forest land were sprayed in the tussock moth project.

PLATE IX

AIRSTRIP OPERATION

Spray planes lined up on the Princeton, Idaho, air strip awaiting the beginning of afternoon spray operations. (1193, Johnson)

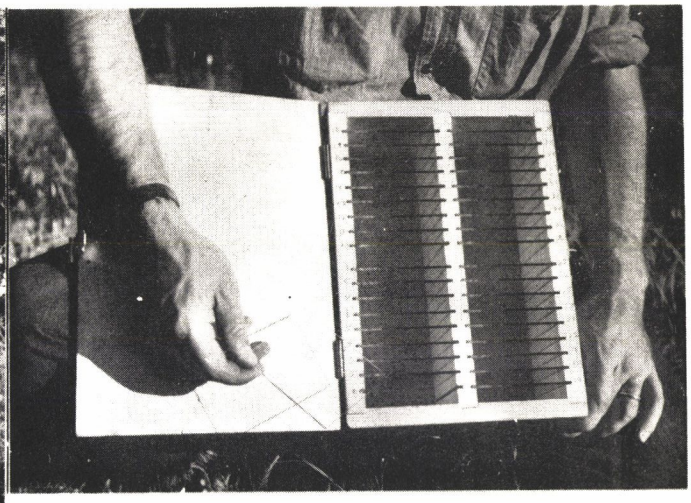
Refilling and servicing of spray planes was quickly done by alert ground crews. DDT tankers, gasoline and oil facilities were grouped in an island at one end of the air strip so that as many as four spray planes could be handled at one time. Average time for refilling spray tanks was 3 minutes, for refueling, 5 minutes. (1236, Johnson)



A rainy day at the Tensed, Idaho, air strip. Over 5 inches of rain fell on the infestation zone during spraying, causing much lost time. Shown here are the single-motored spray planes of the Central Aircraft Company, one of the two spraying contractors. (1239, Johnson)

PLATE X

CHECKING SPRAY COVERAGE



Kit box developed for the project to hold the glass plates used in checking the amount and character of the spray liberated by each spray plane. (1153, Johnson)

A spray checker is shown here setting out a string of 36 glass plates at right angles to the expected flight lines of the spray planes. (1152, Johnson)

The difficulty of recovering the plates after spraying, due to their transparency, was overcome by placing them on squares of newspaper. (1154, Johnson)

PLATE XI

MISCELLANEOUS

Many Douglas-fir farm woodlots suffered heavy defoliation in 1946. Further defoliation in 1947 which would have killed all the trees outright, was averted by timely spraying operations. In the lower photograph a farmer and his wife are up at dawn to watch the spraying of their trees. (1282, 1170, Johnson)

PLATE XII

NORTH IDAHO DOUGLAS FIR TUSSOCK MOTH CONTROL PROJECT

AREAS SPRAYED 1947

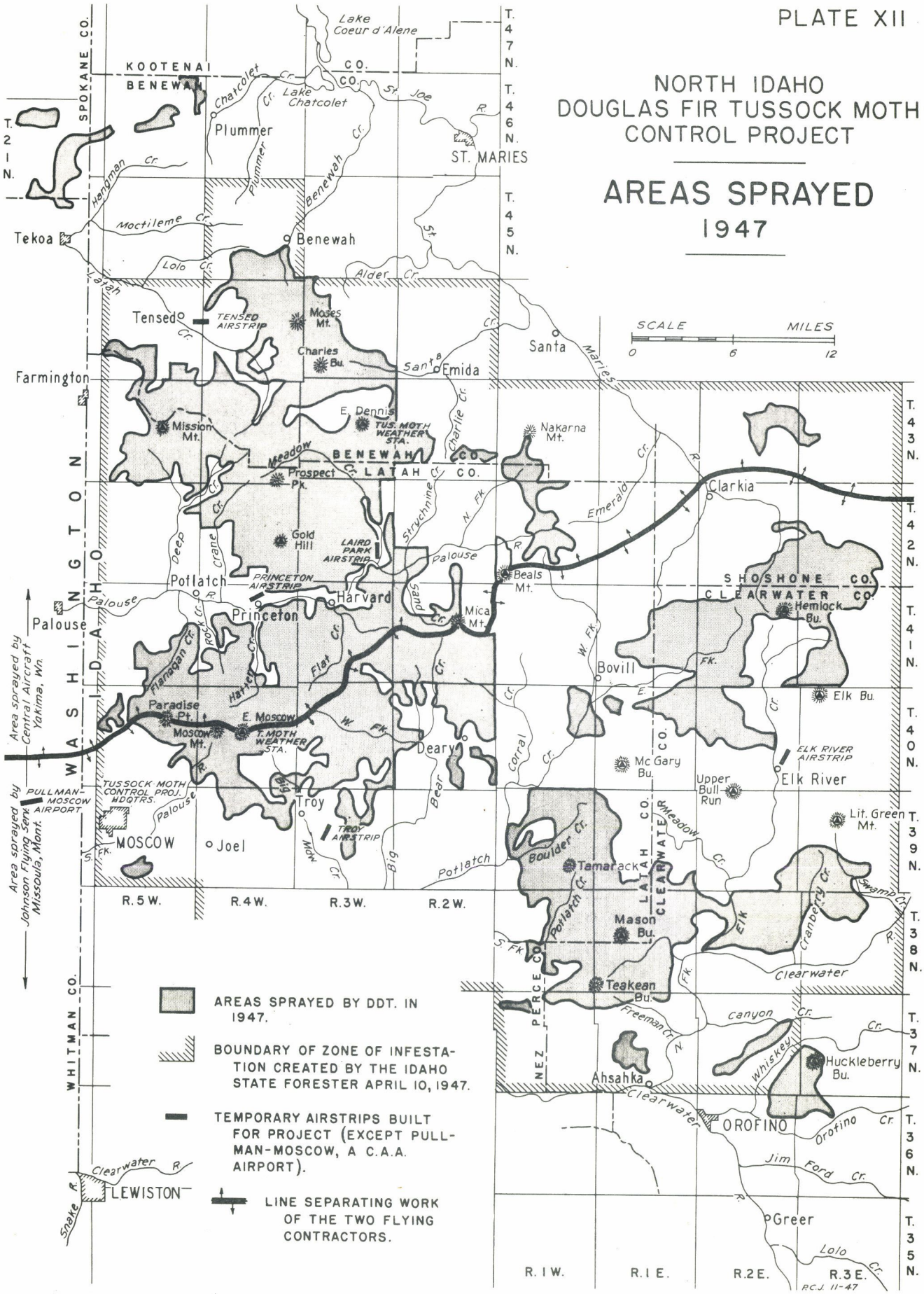
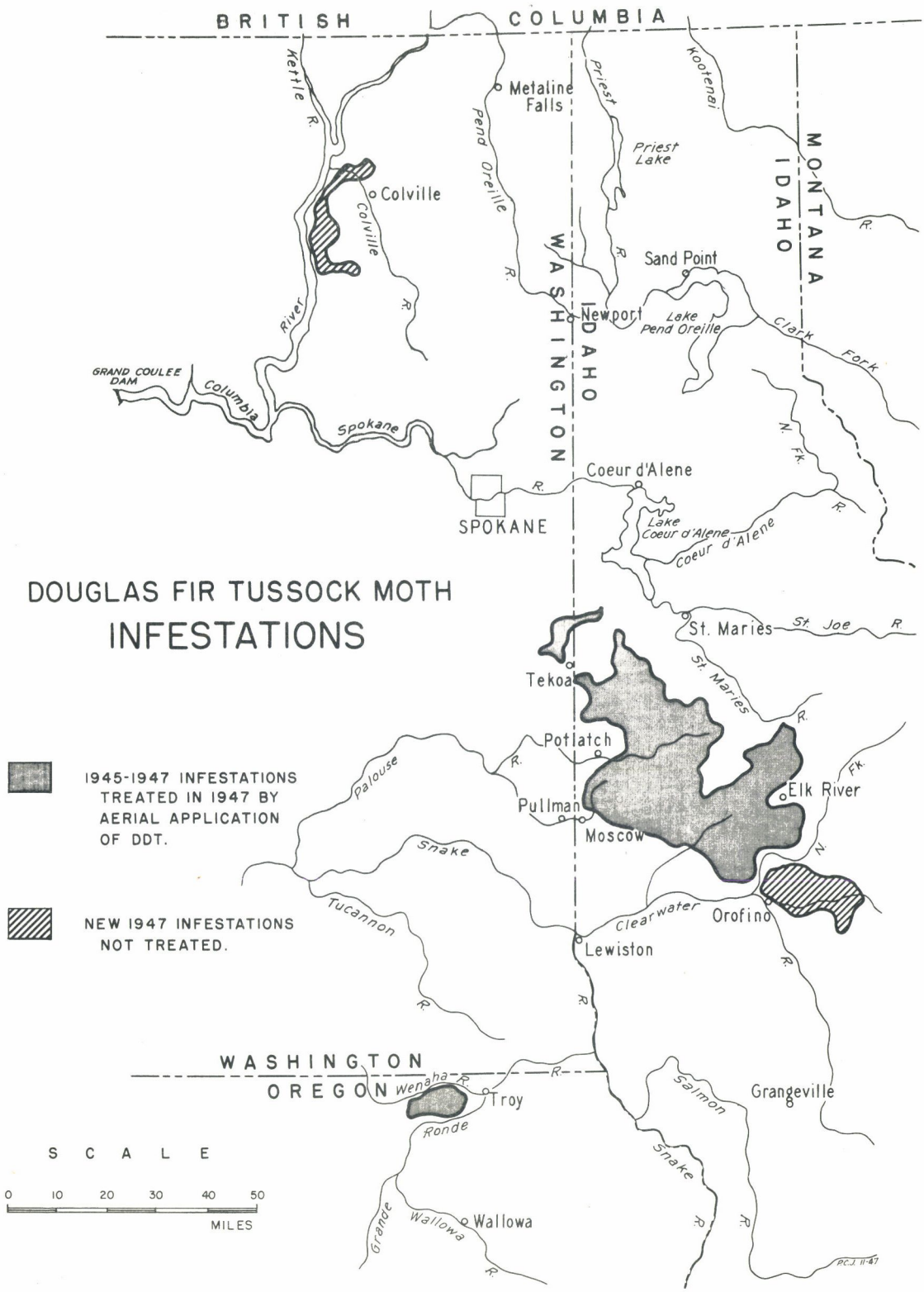


PLATE XIII


BRITISH COLUMBIA
Kettle R.
Metaline Falls
Pend Oreille R.
Priest
Priest Lake
Kootenai
MONTANA
IDAHO
Colville
Colville R.
River
WASHINGTON
IDAHO
Sand Point
Newport
Lake Pend Oreille
Clark Fork
GRAND COULEE DAM
Columbia
Spokane
N. Fk.
Coeur d'Alene
R.
SPOKANE
Lake Coeur d'Alene
Coeur d'Alene
St. Maries
St. Joe R.
DOUGLAS FIR TUSSOCK MOTH
INFESTATIONS
Tekoa
St. Maries R.
Potlatch
Palouse R.
Elk River
Fk.
Pullman
Moscow
Snake
1945-1947 INFESTATIONS TREATED IN 1947 BY AERIAL APPLICATION OF DDT.
Tucannon R.
Clearwater
Orofino
NEW 1947 INFESTATIONS NOT TREATED.
Lewiston
WASHINGTON
OREGON
Wenaha R.
Troy
Grangeville
Salmon
Ronde
Snake R.
S C A L E
0 10 20 30 40 50
MILES
Grande Ronde R.
Wallowa
Wallowa R.
PC.J. 11-47

COMPARISON OF NORMAL AND 1947 SEASONAL BROOD DEVELOPMENT

DOUGLAS FIR TUSSOCK MOTH

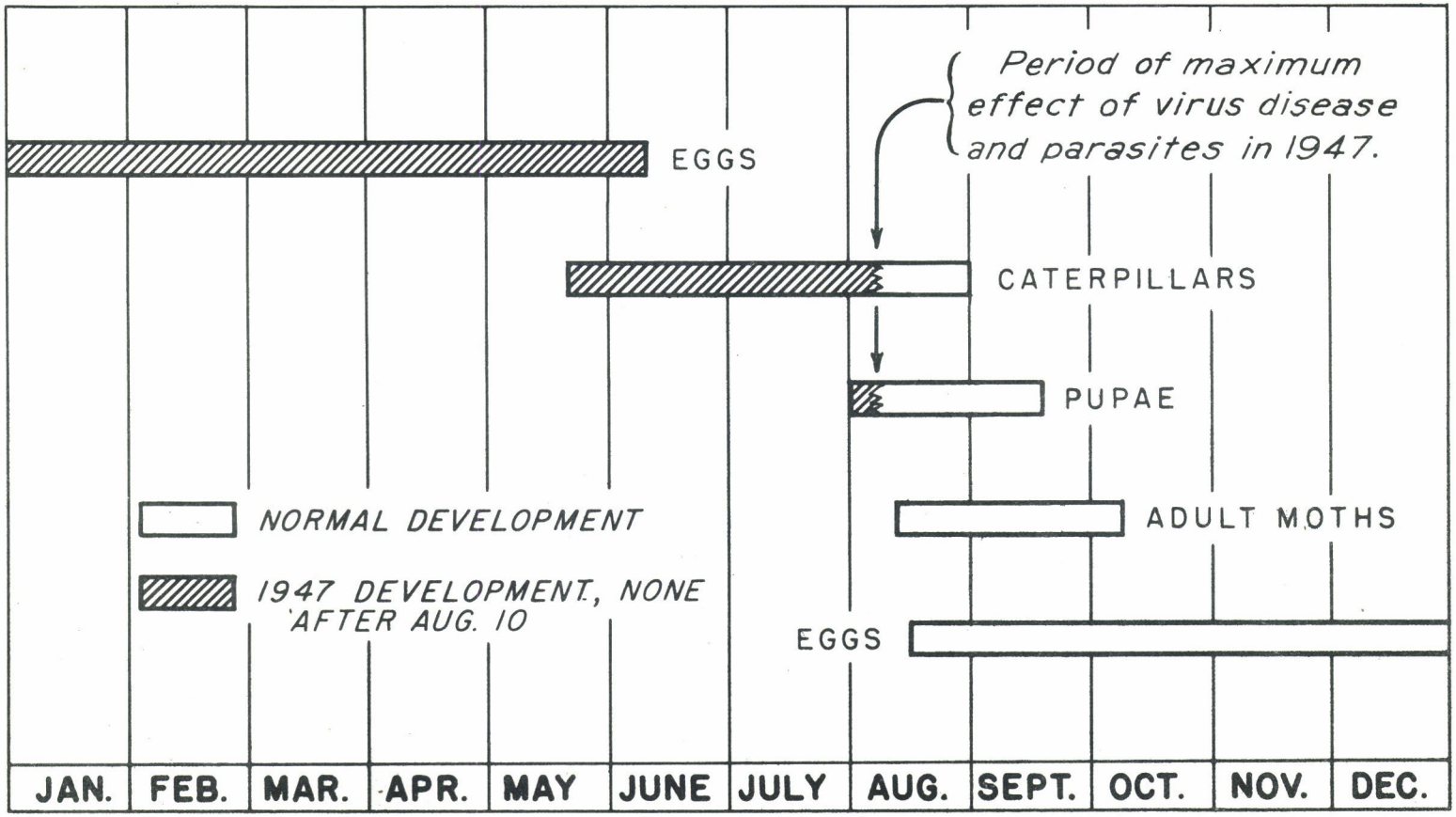


PLATE XIV

PLATE XV

NATURAL CATERPILLAR MORTALITY

Upper photograph (1295, Johnson) shows bodies of virus-killed tussock moth caterpillars clustered around the base of an infested tree near Weippe, Idaho. Toothpicks have been inserted along side each caterpillar to show the concentration in 1 square foot. Lower photograph (1290, Johnson) is a close-up of the same scene.